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THE ANTISEPTIC AND DETOXIFYING ACTION OF ZINC PEROXIDE ON CERTAIN SURGICAL AEROBIC, ANAEROBIC AND MICRO-AEROPHILIC BACTERIA

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THE SUCCESSFUL treatment with zinc peroxide of surgical infections due to anaerobic and micro-aerophilic organisms has been reported in previous communications[1, 2, 3, 4, 5, 6] and confirmed by a number of authors.[7, 8, 9, 10] These reports have included chronic undermining, burrowing ulcers on all parts of the body surface due to the micro-aerophilic hemolytic streptococcus; progressive bacterial synergistic gangrene and gas gangrene after débridement; fusospirochetal infections of the mouth and neck, as well as human bites infected with these organisms; chronic ulcerations of the vagina; perirectal abscesses and deep pelvic abscesses in which anaerobic streptococci play an important part, and other malodorous infections. Zinc peroxide has also been advocated as a prophylactic dressing after the débridement of recent accidental wounds in which the organisms of tetanus or gas gangrene, aerobic hemolytic streptococci, or anaerobic hemolytic and nonhemolytic streptococci are likely contaminants.[11]

The preliminary tests of the action *in vitro* of our early preparations of zinc peroxide had demonstrated its bactericidal effect upon these anaerobic and micro-aerophilic organisms and certain aerobic bacteria. A more comprehensive study was delayed because we found that different preparations gave different results, and that the commercial product had not been standardized. We soon found that there were certain physical and chemical differences between the effective and ineffective preparations which permitted us to set up a tentative standard of minimum requirements. The difficulties attendant upon this standardization and how they were overcome have been detailed in a previous paper.[3]

In this country, zinc peroxide has been manufactured by three firms: Du Pont, Merck and Mallinckrodt. Other chemical firms have marketed one of these three products or one of several different imported preparations. At present Du Pont is the only firm able to manufacture a product which meets the specifications we have set up. The Merck and Mallinckrodt zinc peroxides

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were found ineffective both *in vivo* and *in vitro*, and this fact was called to the attention of these firms. Merck's subsequent attempts to make a suitable product were unsuccessful and they are now planning to market the standardized product made by the Du Pont Chemical Co. of Niagara Falls, N. Y., under the distinctive name "Z. P. O." This can be relied upon to give consistent results both clinically and experimentally. This "Medicinal Grade Zinc Peroxide" must be heated in an oven for four hours at 140° C. in quantities not larger than 250 Gm. For clinical use we have found 15 to 20 Gm. lots most satisfactory. This heating not only sterilizes the zinc peroxide but, in some manner, mobilizes the oxygen. After sterilization the material may be tested easily for effectiveness as follows: Approximately 5 Gm. are added to 50 cc. of distilled water and allowed to sediment at room temperature. The sediment should form quickly as a flocculent curd; the supernatant should be clear. Within an hour bubbles of gas should form in the sediment and lift it up. These three conditions should always prevail. The next two tests are optional. The amount of gas liberated from 5 Gm. suspended in 125 cc. of distilled water at 37.5° C. may be measured by the displacement of water and should be at least 4 cc. after one hour and 12 cc. after 24 hours. The amount of hydrogen peroxide in the filtered supernatant fluid may also be determined and should be approximately 0.0009 per cent after two hours' incubation of a 5 per cent zinc peroxide suspension in distilled water at 37.5° C.

With this standardized effective material we have recently made a comprehensive study of its action *in vitro* on the organisms found to be the cause of, or associated with, surgical infections.

Scope of Investigation.—In testing the bacteriostatic and bactericidal action of antiseptics *in vitro*, certain variables have been found to be important. The concentration of the antiseptic; the size of the bacterial inoculum; the duration of contact of the organisms with the antiseptic; and the composition of the medium. Not only do different species vary in their sensitivity to any given antiseptic, but individual strains within the same species may also show variations. All of these factors have been considered in the present study.

Technic.—The basic technic in these experiments was concerned with the determination of the increase or decrease in the number of viable organisms when zinc peroxide was added to the culture medium.

The medium used in making the zinc peroxide suspensions was a 1 per cent proteose peptone infusion broth made from beef heart, tubed in 10 cc. amounts. The p_H of this medium was 7.4 to 7.6 except as otherwise noted. The broth was boiled for 15 minutes, cooled rapidly and immediately inoculated with the test organisms. In certain experiments horse serum or sheep's whole blood was added to the broth.

The required amounts of zinc peroxide were weighed out under sterile precautions from batches previously sterilized for clinical use. At times, the addition of zinc peroxide to the medium tended to increase the alkalinity. No lot of zinc peroxide was used for these tests in which the p_H of the zinc peroxide suspensions was more than 8.2 at the beginning of the experiment.

In some instances this necessitated using an acid broth in making the 10 and 20 per cent suspensions.

The standard inoculum was 0.5 cc. of an 18-hour culture of the test strain. In determining the effect of varying the size of the inoculum, decimal dilutions of 0.5 cc. of the 18-hour culture were also used.

The number of viable organisms per cubic centimeter in the seeded tubes before the addition of zinc peroxide was determined by decimal dilution series in 1 per cent dextrose broth, and platings on blood agar of 0.1 cc. of the 10^{-3}, 10^{-4}, and 10^{-5} dilutions. All tubes were shaken 100 times to insure an even distribution of the organisms before transfers were made. In some experiments blood agar pour-plates were made using 0.2 cc. from the tubes in the dilution series as the bacterial inoculum. Duplicate and triplicate platings were made and the colony counts averaged. These counts are included in the tables as the "estimated number of colonies under bacteriostatic conditions."

The seeded zinc peroxide suspensions, together with a control tube for the normal rate of multiplication of the organisms, were incubated at 37.5° C. At definite intervals, the number of viable organisms was determined as previously described. The presence of viable bacteria after 24 hours' incubation was further checked by transferring 0.2 cc. from the experimental tubes to tubes of 0.2 per cent dextrose cooked meat medium. Dilution series and platings were incubated for 48 hours, readings being made after 24 and 48 hours.

Although anaerobic and micro-aerophilic organisms will not grow on the surface of solid media in the presence of molecular oxygen, many strains will multiply in deep tubes of liquid media if the medium is boiled and then cooled rapidly immediately prior to incubation. If growth in the control tubes seeded with an anaerobic or micro-aerophilic strain was satisfactory under aerobic conditions, the experimental set-up was incubated aerobically. If strict anaerobiosis was required, the tubes were sealed with vaseline plugs. These seals were not always satisfactory, as, at times, the liquid was forced up over the seal. We wished, however, to avoid using an anaerobic jar for the experimental set-up since we had found that some of the oxygen liberated by the zinc peroxide was removed from the medium under these conditions. The dilution series and platings were always incubated in an anerobic jar if the test organisms had at any time shown a preference for anaerobic environment.

Special technic proved necessary for those organisms that grew poorly in the standard test medium, and this will be described in connection with the tests on these organisms.

Experimental Data.—In reporting the results of our studies we have divided the organisms tested into the following groups: (I) Hemolytic streptococci (anaerobic, micro-aerophilic and aerobic). (II) Aerobic organisms other than hemolytic streptococci (pneumococci, staphylococci, *E. coli, B. proteus, B. pyocyaneus,* and *alpha* streptococci). (III) Spore-bearing anaerobic bacilli (*Cl. welchii, Cl. tetani, Cl. histolyticum, Cl. sporogenes, Cl. novyi, Cl. sordellii* and *Cl. œdematis maligni*). (IV) Nonspore-bearing an-

aerobic bacteria (anaerobic and micro-aerophilic nonhemolytic streptococci, *B. fusiformis* and *B. necrophorus*).

GROUP I.—Hemolytic Streptococci: Hemolytic streptococci may be subdivided on the basis of the different oxygen tensions required for growth. The majority of the strains are aerobic, some strains are micro-aerophilic, and others obligately anaerobic. The bacteriostatic and bactericidal effect of zinc peroxide *in vitro* has been determined on strains of all three groups. An analysis of preliminary experiments showed that differences in individual susceptibility of strains of the same species was best brought out by the comparison of the results of four hours' incubation of the test organisms in 0.5 per cent zinc peroxide suspensions.

TABLE I

DIFFERENCES IN THE SUSCEPTIBILITY OF INDIVIDUAL STRAINS OF HEMOLYTIC STREPTOCOCCUS TO THE BACTERICIDAL ACTION OF ZINC PEROXIDE AFTER FOUR AND TWENTY-FOUR HOURS INCUBATION AT 37.5°C. IN A 0.5 PER CENT SUSPENSION IN INFUSION BROTH

Plate Colony Counts: 0.2 cc.—10^{-2} Dilution of Experimental Tubes
48-hr. Readings

Strain	Est. No. of Bacteria at the Start*	Culture Control After		0.5 Per Cent ZnO_2 in Medium After	
		4 hrs.	24 hrs.	4 hrs.	24 hrs.
Anaerobic					
D-	4900	++++	++++	0	0
K-	2950	++++	++++	1	0
Micro-aerophilic					
L-†		++++	++++	0	0
M-†	2100	++++	++++	0	0
Sa-†	3600	++++	++++	130	0
Sei-†	4300	++++	++++	21	0
Bo-	5300	++++	++++	108	0
R-‡	4450	++++	++++	100	0
				40	0
Ma-	2400	++++	++++	257	0
Ke-	1900	++++	++++	51	0
Ko-	3000	++++	++++	320	0
St-	2800	++++	++++	43	0
Be-	4100	++++	++++	52	0
Si-	5600	++++	++++	97	0
At-	1980	++++	++++	42	0
Aerobic					
C-	2700	++++	++++	250	0
En-	2400	++++	++++	360	0
Ei-	2100	++++	++++	250	0
	4900	++++	++++	300	0
Do-	3800	++++	++++	600	0
F-	2000	++++	++++	250	0
Sac-	5200	++++	++++	680	0

* Calculated from platings of decimal dilutions of control tube before incubation.
† These strains were growing only anaerobically on solid media when the tests were made.
‡ Represents one test with different Lots of zinc peroxide.

(A) *Variations Between Anaerobic, Micro-aerophilic and Aerobic Strains.*—Only two obligately anaerobic strains of hemolytic streptococci have been isolated in this laboratory: one from a lung abscess, the other from a wound infection following an appendicectomy. Twenty strains of micro-aerophilic hemolytic streptococci recovered from chronic undermining, burrowing ulcers

have been tested. It was not possible to test all micro-aerophilic strains before aerobic growth became well established, as some strains became oxygen tolerant after two or three generations on laboratory media. The aerobic hemolytic streptococci tested include strains isolated from infected burns, various types of wound infections, acute hemolytic streptococcus gangrene and septicemias. Table I gives the results of some of the tests made on these three groups of hemolytic streptococci. We realize that these colony counts may represent chains as well as single cocci.

All three groups of hemolytic streptococci proved sensitive to the bactericidal action of zinc peroxide *in vitro*. The obligately anaerobic strains were most susceptible. The micro-aerophilic strains which were growing only anaerobically on solid media at the time the tests were made seemed to be more sensitive than the strains which had accustomed themselves to free oxygen in their environment. The aerobic strains were slightly more resistant. These differences in degree of sensitivity could be judged only by comparison of the results of the four-hour incubation period. When the time of action was 18 or 24 hours, all subcultures from the zinc peroxide suspensions failed to grow.

(B) *Percentage of Zinc Peroxide in Suspension and Time of Action.*—The following experiment was designed to ascertain if the percentage of zinc peroxide added to the medium and the time of action had a direct relationship to the number of viable organisms in such suspensions. The effect of the addition of 20, 10, 5, 1 and 0.5 per cent zinc peroxide to the seeded broth tubes was determined after one, two, four, six and 24 hours' action at 37.5° C. by decimal dilution series and platings as previously described. The results of the platings in four such experiments are given in Table II. The results of the platings of the tubes in the dilution series are given in preference to recording growth or absence of growth in the tubes of the decimal dilutions because of false negatives in the low dilutions.

It is evident that the larger the percentage of zinc peroxide in suspension, the more rapid is its bactericidal action. However, with smaller percentages, an increase in the time of action results in a sterilization of the culture. After 24 hours' incubation, with the percentages of zinc peroxide used in this experiment, we were unable to subculture the hemolytic streptococcus from the zinc peroxide suspensions. We at no time observed any significant increase in the number of viable organisms after zinc peroxide had been added to the medium. Not only was there a great reduction in the number of colonies in the platings from the zinc peroxide suspensions, but there was a delay in the development of these colonies. After 24 hours' incubation of the platings from these suspensions, the colonies were poorly developed. Some were pin-point in size and nonhemolytic; others showed a zone of greenish discoloration around the colony; relatively few were hemolytic. All colonies on the control platings developed *beta* hemolysis within 24 hours. Even after 48 hours' incubation of the platings from the zinc peroxide suspensions, many of the colonies were small and showed *alpha* hemolysis only.

TABLE II

EFFECT OF VARIATIONS IN THE PERCENTAGE OF ZINC PEROXIDE IN SUSPENSION AND IN THE TIME OF ACTION ON THE BACTERICIDAL ACTION OF ZINC PEROXIDE ON TWO AEROBIC AND TWO MICRO-AEROPHILIC STRAINS OF HEMOLYTIC STREPTOCOCCUS

Plate Colony Counts: 0.1 cc.–10^{-3} Dilution of Experimental tubes
48-hr. Readings

Strain	Est. No. of Bacteria at the Start	Per Cent ZnO_2 in Medium	Time of Action				
			1 hr.	2 hrs.	4 hrs.	6 hrs.	24 hrs.
E	120	20	3	0	0	0	0
		10	13	0	0	0	0
		5	19	10	0	0	0
		1	65	15	3	2	0
		0.5	113	33	18	3	0
		Control p_H 8.2	200	350	++++	++++	++++
		Control p_H 7.6	+++	++++	++++	++++	++++
Ki	1180	20	300	28	0	0	0
		10	380	36	0	0	0
		5	325	40	0	0	0
		1	300	200	73	48	0
		0.5	380	200	99	79	0
		Control p_H 8.2	+++	++++	++++	++++	++++
		Control p_H 7.6	+++	++++	++++	++++	++++
S*	180	20	12	2	0	0	0
		10	30	17	0	0	0
		5	65	15	0	0	0
		1	74	20	0	0	0
		0.5	126	72	7	0	0
		Control p_H 8.2	+++	++++	++++	++++	++++
		Control p_H 7.6	+++	++++	++++	++++	++++
M*	940	20	23	0	0	0	0
		10	37	19	0	0	0
		5	+	25	0	0	0
		1	+	38	0	0	0
		0.5	+	36	0	0	0
		Control p_H 8.2	+++	+++	++++	++++	++++
		Control p_H 7.6	+++	+++	++++	++++	++++

* These micro-aerophilic strains grew only anaerobically on solid media at the time the tests were made.

NOTE: Although 40 to 50 per cent suspensions of zinc peroxide are used clinically, such heavy suspensions *in vitro* resulted in a paste-like mass after a few hours' incubation. Since it was impossible to insure an even distribution of organisms, the transference of adequate amounts entailed carrying over quantities of zinc peroxide sufficient to nullify the results.

TABLE III

BACTERICIDAL EFFECT OF FILTRATES FROM ZINC PEROXIDE SUSPENSIONS IN INFUSION BROTH ON HEMOLYTIC STREPTOCOCCI

Time of Action: 4 and 24 hrs. at 37.5° C.
48-hr. Readings

Filtrates from ZnO_2 Suspensions	Highest Dilution Showing Growth. Time of Action		Plate Colony Counts 0.1 cc.–10^{-3} Time of Action		
	4 hrs.	24 hrs.	0 hrs.	4 hrs.	24 hrs.
1%—A	10^{-5}	—	910	62	0
B	10^{-4}	—	910	43	0
5%—A	10^{-3}	—	910	1	0
B	10^{-3}	—	910	9	0
0%—Control	10^{-7}	10^{-9}	910	++++	++++

The absence of growth or false negatives in certain low dilutions of the broth series suggested that a growth-inhibitory substance was being carried over into the lower decimal dilutions from the original suspensions. One and 5 per cent suspensions of zinc peroxide were made in 100 cc. of beef heart infusion broth, incubated for two hours at 37.5° C. and then centrifuged and filtered through a Chamberland filter. The filtrates were divided into 10 cc. amounts and seeded with 0.5 cc. of an 18-hour culture of the hemolytic streptococcus. A control tube of 10 cc. broth plus 0.5 cc. of the culture was also set up. Viable counts were made after four and 24 hours' incubation at 37.5° C. The results of one such experiment are given in Table III.

We then tested the broth filtrates for hydrogen peroxide using the potato-benzidine test. In the unseeded filtrates the reaction was positive through dilutions 1 :4 in the 1 per cent and 1 :8 in the 5 per cent filtrate. A comparison with known dilutions of reagent hydrogen peroxide showed that these concentrations, 0.0018 and 0.0037 per cent, respectively, not only inhibited the growth of hemolytic streptococci but caused a marked reduction in the viable count. The concentration of hydrogen peroxide in these broth filtrates decreased to approximately one-half after four hours' incubation at 37.5° C. After 24 hours' incubation, both the 1 and 5 per cent filtrates were negative for peroxide within the limits of our tests. We believe that the hydrogen peroxide present in the supernatant broth of zinc peroxide suspensions plays an important rôle in the action of zinc peroxide *in vitro*, especially since the concentration of this peroxide remains constant as long as zinc peroxide is in suspension in the medium.

(C) *Variations in Size of Inoculum.*—The effect of varying the size of the inoculum was also tested. The inocula used were 0.5 cc., 0.05 cc., 0.005 cc., and 0.0005 cc. of an 18-hour culture. The percentage of zinc peroxide in suspension was 1 and 0.5 per cent, the time of action four and 24 hours at 37.5° C. Viable counts were made as previously described. The results of the platings only will be given here (Table IV).

When the time of action was 24 hours, the dilution series and platings made from the zinc peroxide suspensions showed no growth, while growth from the control tubes was abundant. The size of the inoculum had a direct correlation with the survival of organisms after four hours, but not after 24 hours.

The following experiment demonstrated that certain individual organisms were more resistant than others. A 0.5 per cent suspension of zinc peroxide in neopeptone water was seeded with a strain of hemolytic streptococcus recently isolated from an undermining ulcer of the neck. The percentage of matt to glossy colonies was determined before and after four hours' incubation at 37.5° C. Platings were made on rabbit's blood agar (Table V).

This experiment was repeated with similar results. Todd,[12] in determining the relative sensitivity of matt and glossy variants to hydrogen peroxide, found that the glossy colonies were definitely less sensitive. In three out of

TABLE IV

EFFECT OF SIZE OF INOCULUM ON BACTERICIDAL ACTION OF ZINC PEROXIDE IN VITRO ON HEMOLYTIC STREPTOCOCCUS

Plate Colony Counts: 0.1 cc.–10^{-2} Dilution of Experimental Tubes
Time of Action: 4 hrs. 48-hr. Readings

Strain	Original Inoculum	Est. No. of Bacteria at the Start	Control	ZnO_2 Suspensions 1%	0.5%
C	0.5 cc.	1350	++++	100	125
	0.05 cc.	135	++++	4	3
	0.005 cc.	14	+++	0	0
	0.0005 cc.	2	22	0	0
C	0.5 cc.	800	++++	33	48
	0.05 cc.	80	++++	1	0
	0.005 cc.	8	200	0	0
	0.0005 cc.	1	7	0	0
B*	0.5 cc.	750	++++	100	+
	0.05 cc.	75	++++	40	50
	0.005 cc.	8	125	1	8
	0.0005 cc.	1	10	0	2

* Strain B, relatively resistant strain, isolated after treatment with zinc peroxide.

TABLE V

EFFECT OF INCUBATION IN 0.5 PER CENT ZINC PEROXIDE SUSPENSIONS ON MATT AND GLOSSY VARIANTS OF HEMOLYTIC STREPTOCOCCUS, STRAIN M.M.

Plate Colony Counts: 0.1 cc.–10^{-2} Dilution
48-hr. Readings

Time of Action	Matt Colonies	Glossy Colonies
0 hrs.	400	38
4 hrs.	1	22
24 hrs.	0	0

five strains tested, from four to eight times the concentration of hydrogen peroxide which inhibited the multiplication of matt virulent colonies was necessary for a like inhibition of the glossy or nonvirulent variants.

(D) *Variations with the Addition of Body Fluids to the Medium.*—In an attempt to determine the effect of body fluids on the bactericidal action of zinc peroxide, serum and whole blood were added to the broth medium. Zinc peroxide suspensions were made in beef heart infusion broth, and broth plus horse serum or sheep's whole blood. Control tubes of all three media were also set up. The results of some of these experiments are given in Tables VI and VI A.

Although the bactericidal action of zinc peroxide in media containing blood or serum was somewhat slower, there was a decided reduction in the viable count in the 20, 10 and 5 per cent suspensions when the time of action was four hours. After 24 hours, the suspensions containing 20 or 10 per cent zinc peroxide were sterilized, regardless of the percentage of body fluids in the medium. There were occasional viable organisms in the 5 per cent suspensions. The percentage of body fluids in the broth influenced the results in the 1 and 0.5 per cent suspensions. The bactericidal action of the zinc peroxide decreased as the percentage of body fluids increased, although in no instance was there a

TABLE VI

BACTERICIDAL ACTION OF ZINC PEROXIDE ON HEMOLYTIC STREPTOCOCCI IN BROTH CONTAINING 10 PER CENT OF SERUM OR DEFIBRINATED BLOOD

Plate Colony Counts: 0.1 cc.–10^{-3} Dilution of Experimental Tubes
48-hr. Readings

Strain	Est. No. of Bacteria at the Start	Time of Action	Controls			Zinc Peroxide Suspensions								
						5 Per Cent			1 Per Cent			0.5 Per Cent		
			Pl.	+ Ser.	+ Bl.	Pl.	Ser.	Bl.	Pl.	Ser.	Bl.	Pl.	Ser.	Bl.
S	520	4 hrs.	+++	++++	++++	35	40	44	30	39	125	68	325	277
C	500	4 hrs.	+++	++++		0	5		18	250		85	+++	
C	288	4 hrs.	+++		++++	0		37	0		196	0		230
S	520	24 hrs.	++++	++++	++++	0	0	0	0	24	110	0	125	100
C	500	24 hrs.	++++	++++		0	0		0	3		0	85	
C	288	24 hrs.	++++		++++	0		0	0		0	0		22

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significant rise in the viable count. Some decrease in the bactericidal action of zinc peroxide in media containing blood or serum is to be expected since the nutritive qualities of the medium are enhanced, and the effect of the hydrogen peroxide in the supernatant broths of such suspensions would be lessened by the action of the catalase introduced into the medium in the serum or blood.

TABLE VI A

EFFECT OF VARIOUS PERCENTAGES OF SHEEP'S WHOLE BLOOD IN BROTH MEDIUM ON BACTERICIDAL ACTION OF ZINC PEROXIDE IN VITRO ON HEMOLYTIC STREPTOCOCCUS, STRAIN N

Plate Colony Counts: 0.1 cc.–10^{-3} Dilution of Experimental Tubes
48-hr. Readings

Per Cent ZnO_2 Suspension	Est. No. of Bacteria at the Start	Time of Action	Per Cent Blood in Broth Medium				
			0	100	50	25	10
0-Control	460	4 hrs.	3300	++++	++++	++++	++++
20	460	4 hrs.	0	1	85	43	47
10	460	4 hrs.	0	0	45	109	89
5	460	4 hrs.	0	60	96	80	92
1	460	4 hrs.	37	105	138	88	110
0.5	460	4 hrs.	36	365	260	319	330
0-Control	460	4 hrs.	++++	++++	++++	++++	++++
20	460	4 hrs.	0	0	0	0	0
10	460	4 hrs.	0	0	0	0	0
5	460	4 hrs.	0	0	1	2	0
1	460	4 hrs.	0	338	302	4	55
0.5	460	4 hrs.	0	500	359	54	66

DEVELOPMENT OF RESISTANCE IN VIVO AND IN VITRO TO THE BACTERICIDAL ACTION OF ZINC PEROXIDE

Before the zinc peroxide became standardized, we attempted to study changes in the flora of lesions treated with zinc peroxide through daily bacteriologic examinations. In some cases, the hemolytic streptococci persisted after what seemed to be adequate contact with the zinc peroxide. We thought it important to determine whether the strains recovered from such lesions after treatment with zinc peroxide were more resistant to its bactericidal action *in vitro* than the strains isolated before the zinc peroxide had been used.

In the experiments reported here, the strains of hemolytic streptococci were recovered from an undermining ulcer of the hand. When treated with a Lot of zinc peroxide later shown to be below standard, this lesion showed initial rapid clinical improvement and cultures became negative for hemolytic streptococci except in one area where the infection still persisted after the major portion of the ulcer had healed. The bactericidal action of zinc peroxide *in vitro* on the strain recovered from this area was compared with its action on the original strain. The strain isolated after treatment was much more resistant. It was not possible to subculture the original strain from a seeded 1 per cent suspension of zinc peroxide in broth after the four-hour incubation period, whereas viable organisms were still present in the suspensions seeded with the recently isolated strain after 24 hours' incubation. Table VII, which gives the plate colony counts in this experiment, will illustrate these differences in susceptibility.

TABLE VII

DEVELOPMENT OF RESISTANCE IN VIVO TO BACTERICIDAL ACTION OF ZINC PEROXIDE IN VITRO

Plate Colony Counts: 0.2 cc.–10^{-2} Dilution of Experimental Tubes
48-hr. Readings

Strain	Est. No. of Bacteria at the Start	Time of Action	Culture Control	1% ZnO_2 Suspension
L-I*	4500	4 hrs.	++++	0
L-II†	3700	4 hrs.	++++	++
L-I	4500	24 hrs.	++++	0
L-II	3700	24 hrs.	++++	50

* Strain L-I isolated before treatment with ZnO_2.
† Strain L-II isolated after treatment with ZnO_2.

It was results such as this that made us realize the dangers attendant upon the clinical use of zinc peroxide which fell below the standards we had set up for an effective preparation, since the development *in vivo* of resistance to the bactericidal action of zinc peroxide *in vitro* was most often observed in cultures from lesions treated with relatively ineffective lots of zinc peroxide. Not only did the infection fail to respond to treatment when substandard material was used, but the organisms seemed to acquire resistance to effective material.

We also observed from the study of daily cultures of lesions under treatment with effective zinc peroxide that, as the infection was brought under control clinically, the streptococcus colonies lost their hemolytic character when plated on blood agar, and the zone around the colony became greenish. This was a constant finding in the chronic undermining, burrowing type of ulcer. This variant might persist in the wound until complete healing occurred, but no further extension of the lesion took place if no hemolytic organisms were present. When the growth-inhibiting action of zinc peroxide on the multiplication of these green-producing streptococci was tested, they were found to be relatively resistant. No appreciable bacteriostatic or bactericidal action was evident after 24 hours' incubation of a 1 per cent suspension of zinc peroxide seeded with 0.5 cc. of an 18-hour broth culture.

We attempted to duplicate this change from hemolytic to green-producing streptococci *in vitro*. Cultures were not made from single organisms of the hemolytic strain, but single colonies were replated. Both anaerobic and aerobic platings were made. This selection of single colonies was carried out through five generations, so that we could be reasonably sure of no contamination with *alpha* streptococci. It proved relatively easy to produce a green variant if the hemolytic streptococcus culture was incubated in a 1 per cent zinc peroxide suspension for four to six hours, and platings made directly from the zinc peroxide suspension onto blood agar. In most instances, however, the colonies with *alpha* type hemolysis regained their *beta* hemolytic character upon transplantation to fresh blood agar plates or when blood agar pour-plates were made from broth cultures of these colonies. This reversion to type occurred sometimes after one generation, sometimes after two or three. We were successful in obtaining several strains that did not revert to the hemolytic type,

but remained green. These green variants and their hemolytic prototypes were tested for their susceptibility to the antiseptic action of zinc peroxide *in vitro*, and they proved, as had the green types recovered from wounds treated with zinc peroxide, much more resistant to the antiseptic action of zinc peroxide. The results of one such experiment are summarized in Table VIII.

TABLE VIII

VARIATIONS IN SUSCEPTIBILITY TO ZINC PEROXIDE OF HEMOLYTIC STREPTOCOCCUS AND A GREEN VARIANT PRODUCED IN VITRO

Plate Colony Counts: 0.2 cc.–10^{-3} Dilution of Experimental Tubes 48-hr. Readings

Est. No. of Bacteria at the Start	Time of Action	Colony Type	Culture Control	One Per Cent ZnO_2 in Medium
400	4 hrs.	Hem.	++++	7
500	4 hrs.	Green	++++	800
40	4 hrs.	Hem.	++++	0
50	4 hrs.	Green	++++	125
400	24 hrs.	Hem.	++++	0
500	24 hrs.	Green	++++	1000±
40	24 hrs.	Hem.	++++	0
50	24 hrs.	Green	++++	300±

The plate colony counts show that some multiplication of the green variant took place in the 1 per cent zinc peroxide suspensions. However, some bacteriostatic effect is evident since the rate of multiplication in the zinc peroxide suspensions was much less than in the control cultures. The results with the green variant are in sharp contrast to those with the original hemolytic strain where a distinct bactericidal effect was exerted by the zinc peroxide even during the first four hours of incubation.

The Strain C used in this experiment was virulent for mice At the time these tests were made, 0.5 cc. of a 10^{-4} dilution of a six-hour culture in serum broth injected intraperitoneally killed mice within 18 hours. The green variant proved to be nonpathogenic. We had hoped to cause a reversion of the green to the hemolytic form by animal passage but in this we were unsuccessful.

GROUP II.—Aerobic Organisms Other Than Hemolytic Streptococcus: (A) *Pneumococcus.*—We determined the effect of the addition of zinc peroxide to the medium on strains of pneumococcus, Types I, II, and III. The technic was the same as in the experiments in which hemolytic streptococcus was the test organism. A summary of our results is given in Table IX.

Zinc peroxide was found to exert a distinctly bactericidal effect on the pneumococcus. The similarity between the results of the experiments with aerobic hemolytic streptococcus and pneumococcus is very striking. The explanation may lie in the fact that both organisms lack catalase and are, therefore, sensitive to hydrogen peroxide in the culture medium.

The addition of body fluids to the broth medium decreased the bactericidal action of zinc peroxide on pneumococcus. We observed no significant variation in the susceptibility of the different types tested to the antiseptic action of zinc peroxide.

TABLE IX

EFFECT OF VARIATIONS IN THE PERCENTAGE OF ZINC PEROXIDE IN SUSPENSION IN THE BROTH MEDIUM AND IN THE TIME OF ACTION ON PNEUMOCOCCUS IN VITRO

Plate Colony Counts: 0.1 cc.–10^{-3} Dilution of Experimental Tubes
48-hr. Readings

Type	Est. No. of Bacteria at the Start	Per Cent ZnO_2 in Suspension	Time of Action 1 hr.	2 hrs.	4 hrs.	6 hrs.	24 hrs.
I	600±	20	105	12	0	0	0
		10	150	52	0	0	0
		5	440	210	0	0	0
		1	310	103	89	0	0
		0.5	390	121	27	0	0
		Control	700	+++	+++	++++	++++
II S39	930	20	15	0	0	0	0
		10	170	0	0	0	0
		5	210	35	4	0	0
		1	300	138	14	0	0
		0.5	350	204	62	0	0
		Control	1000	++	+++	++++	++++
II R129	760	20	53	0	0	0	0
		10	240	0	0	0	0
		5	250	9	0	0	0
		1	230	18	11	0	0
		0.5	510	94	23	0	0
		Control	1500	+++	+++	++++	++++
III Smith	600±	20	4	0	0	0	0
		10	31	0	0	0	0
		5	39	10	21	0	0
		1	43	19	9	0	0
		0.5	67	38	24	0	0
		Control	1000	+++	+++	++++	++++

(B) *Staphylococcus.*—Both hemolytic and nonhemolytic strains of *staphylococcus aureus* were tested. The strains used had been isolated from septicemias, wound infections and carbuncles. As in previous experiments, the effect of the percentage of zinc peroxide in suspension and of the time of action was determined. Decimal dilution series made after four hours' incubation of the control and zinc peroxide suspensions revealed no appreciable difference in the number of viable organisms in the control and experimental tubes. When the time of action was 24 hours, there was a difference in the viable counts of the control tube and the seeded zinc peroxide suspensions in the higher concentrations. Table X summarizes the results of four such experiments.

TABLE X

EFFECT OF ADDITION OF ZINC PEROXIDE TO THE BROTH MEDIUM ON THE GROWTH OF STAPHYLOCOCCUS AUREUS

Strain	Before Addition ZnO_2	Time of Action	Culture Control	Zinc Peroxide in Suspension 30%	20%	10%	5%	1%
S	10^{-6}*	24 hrs.	10^{-10}		10^{-6}	10^{-7}	10^{-9}	10^{-10}
B	10^{-7}	24 hrs.	10^{-10}	10^{-6}	10^{-6}	10^{-8}	10^{-10}	10^{-10}
M	10^{-6}	24 hrs.	10^{-10}	10^{-4}	10^{-4}	10^{-6}	10^{-10}	10^{-10}
O	10^{-6}	24 hrs.	10^{-10}	10^{-5}	10^{-5}	10^{-8}	10^{-10}	10^{-10}

* Highest dilution showing growth.

The 10^{-1} tube in the dilution series from the 20 and 10 per cent suspensions at times showed no visible multiplication. In only one experiment did the false negatives extend beyond this dilution.

Plate colony counts indicated some bactericidal action of zinc peroxide in the 30 and 20 per cent suspensions when the time of action was 24 hours. In one experiment in the transfers from the 20 per cent suspensions the number of viable organisms was reduced from an estimated 930 to 120, in another from 1,250 to 370. There was some bacteriostatic action evident in the 10 per cent suspensions, but no significant inhibition of multiplication in the 5 or 1 per cent suspensions.

Addition of whole blood or serum to the broth medium made no appreciable change in the results. There was no significant difference in the susceptibility of individual strains, whether hemolytic or nonhemolytic.

Although there is evidence of some bactericidal action of zinc peroxide on *staphylococcus aureus* when large percentages were used in the broth medium, we have classed it as an organism relatively resistant to the action of zinc peroxide *in vitro* since little bacteriostatic or bactericidal effect is apparent during the first four hours' incubation of seeded zinc peroxide suspensions, even when amounts as high as 20 per cent are added to the medium.

(C) *E. Coli.*—The strains of *E. coli* tested were isolated from wound and urinary infections. They included *B. acidi lactici, B. coli communis* and *B. coli communior.* Representatives of these three groups did not differ in their susceptibility to the action of zinc peroxide *in vitro.* The results of three of the experiments made to determine the effect of variations in the percentage of zinc peroxide added to the culture medium are given in Table XI. The time of action was four and 24 hours at 37.5° C. The results of the four-hour determinations are not included in the table as there was no difference in growth in the dilutions of the control tubes and any of the zinc peroxide suspensions.

TABLE XI

EFFECT OF ADDITION OF ZINC PEROXIDE TO BROTH MEDIUM ON GROWTH OF E. COLI

Results of Decimal Dilutions of Experimental Tubes
48-hr. Readings

Strain	Before Addition ZnO_2	Time of Action	Culture Control	Zinc Peroxide in Suspension 20%	10%	5%	1%	0.5%
B	10^{-6}	24 hrs.	10^{-9}	10^{-6}	10^{-8}	10^{-8}	10^{-9}	10^{-9}
P	10^{-7}	24 hrs.	10^{-9}	10^{-6}	10^{-7}	10^{-9}	10^{-9}	
I	10^{-6}	24 hrs.	10^{-9}	10^{-2}	10^{-6}	10^{-8}	10^{-9}	10^{-9}

The results of the plate colony counts were in accord with the readings of the dilution series.

No significant bactericidal effect of the addition of zinc peroxide to the medium on *E. coli* was evident except when percentages as high as 20 per cent were used. A decrease in the viable count was observed only when the time of action was 24 hours. In some experiments 10 per cent zinc peroxide in suspension exerted a slight bacteriostatic effect. Since no significant bacterio-

static or bactericidal effect of zinc peroxide *in vitro* is evident when the time of action is four hours, we have classed *E. coli* as relatively resistant to the antiseptic action of zinc peroxide.

(D) *B. Proteus and B. Pyocyaneus.*—Five strains of *B. pyocyaneus* were tested and three strains of *B. proteus*. All had been isolated from wound infections. Even after 24 hours' incubation of 20 or 10 per cent seeded zinc peroxide suspensions in infusion broth, there were no significant differences in growth in the decimal dilution series or in the plate colony counts from these suspensions and the control tubes to which no zinc peroxide had been added. No bacteriostatic or bactericidal action of zinc peroxide *in vitro* was observed when these organisms were the test strains.

(E) *Alpha Streptococci.*—The following strains of green-producing streptococci were tested: *Streptococcus faecalis*—human stock strain and bovine strain; Bargen's diplococcus—stock strain; green streptococci, isolated from tonsils (two cases), wounds (eight cases), and urinary tract infections (two cases). The effect of additions of zinc peroxide to the medium is illustrated in Table XII.

TABLE XII

EFFECT OF VARIATIONS IN THE PERCENTAGE OF ZINC PEROXIDE IN SUSPENSION AND IN THE TIME OF ACTION ON GREEN-PRODUCING STREPTOCOCCI IN VITRO, STRAINS G AND N

		48-hr. Readings				
		Decimal Dilutions*		Plate Colony Counts		
	Per Cent ZnO_2	Time of Action		0.1 cc.–10^{-4}		
Strain	in Medium	4 hrs.	24 hrs.	0 hrs.	4 hrs.	24 hrs.
G	0-Control	10^{-8}	10^{-9}	85	++++	++++
	20	10^{-7}	10^{-8}	85	139	154
	10	10^{-8}	10^{-8}	85	++++	185
	5	10^{-8}	10^{-9}	85	++++	++++
	1	10^{-8}	10^{-9}	85	++++	++++
N	0-Control	10^{-8}	10^{-8}	203	++++	++++
	20	10^{-7}	10^{-7}	203	157	108
	10	10^{-9}	10^{-8}	203	431	460
	5	10^{-8}	10^{-9}	203	++++	++++
	1	10^{-8}	10^{-8}	203	++++	++++
	0.5	10^{-8}	10^{-8}	203	++++	++++

* Highest dilution showing growth.

In no case did incubation in the zinc peroxide suspensions result in absence of growth when transfers were made into fresh media, even when the time of action was as long as 24 hours at 37.5° C. When 20 or 10 per cent zinc peroxide was in suspension, some slight bacteriostatic but no significant bactericidal action was observed.

SUMMARY.—Two species of aerobic bacteria tested were found to be sensitive to the bactericidal action of zinc peroxide *in vitro*—hemolytic streptococcus and pneumococcus. *Staphylococcus aureus, E. coli, B. pyocyaneus, B. proteus* and *alpha* streptococcus were relatively resistant to its antiseptic action. A possible explanation of this difference will be considered later.

GROUP III.—Anaerobic Spore-Bearing Bacilli: The bactericidal action of zinc peroxide *in vitro* was determined on the following anaerobic spore-bearing

bacilli: *Cl. welchii, Cl. tetani, Cl. histolyticum, Cl. sporogenes, Cl. novyi, Cl. sordellii* and *Cl. œdematis maligni.* The strains of *Cl. welchii* tested were recently isolated from gangrenous lesions. The strains of the other organisms in this group were stock cultures.

Technic.—In testing these spore-bearing bacilli we were confronted with an additional problem, since we had to ascertain the effect of zinc peroxide on both spore and vegetating forms.

Since *Cl. welchii* does not form spores in media containing dextrose, it was possible to test the *in vitro* action of zinc peroxide on cultures presumably spore-free, and on cultures grown in dextrose-free media which were a mixture of vegetating and spore forms. By heating such cultures to 80° C. for 20 minutes, we were able to obtain cultures of spore forms only. With the remaining bacilli in this group we were able to test the action of zinc peroxide only on the spore forms and mixtures of spore and vegetating forms.

In order to reduce the number of spore forms to a minimum when the test organisms were prolific spore formers, the broth cultures used for seeding the experimental set-up were transfers heated to 80° or 85° C. for 20 minutes and then incubated anaerobically for 18 hours.

The bactericidal action of zinc peroxide on the vegetating forms was determined by a comparison of the results of the tests on suspensions containing spores only, and those containing a mixture of spore and vegetating forms. Duplicate series of control tubes and zinc peroxide suspensions were set up. The culture to be used in seeding these series was divided into two lots. One portion was heated to destroy the vegetative forms. One series was inoculated with the heated culture, the other with the unheated. The number of spores and the total viable forms was determined before incubation of the experimental set-up. The technic of these determinations also presented difficulties. In making decimal dilutions, the amount of shaking necessary to insure an even distribution of the organisms reaerated the boiled broth so that the bacilli failed to multiply even under anaerobic conditions in the dilutions where they were few in number. To secure consistent results it was necessary to make the dilutions in one series of broth or saline tubes, and then make transfers from each dilution into fresh tubes of 0.1 per cent cysteine hydrochloride broth, thus preventing the aeration of the medium in the tubes to be incubated. In some instances 5 per cent of serum was added to the tubes in the dilution series in order to provide optimum conditions for the multiplication of the organisms.

In checking the presence of false negatives in the decimal dilutions, colony counts from blood agar pour-plates were often unsatisfactory because of the difficulty in distinguishing the colonies. With the organisms with spreading colony growth, surface platings were not feasible. We finally decided in some cases to transfer 0.1 cc. from the tubes in the decimal dilution series to tubes of 0.2 per cent dextrose cooked meat medium. These tubes were incubated anaerobically for six to ten days before the final readings were made.

Experimental Data.—(A) *Clostridium Welchii.*—Since *Cl. welchii* grew well in the control tubes of boiled liquid media under aerobic conditions, it was not necessary to incubate the experimental set-up anaerobically. Table XIII

gives the plate colony counts in experiments made to determine the effect of variations in the percentage of zinc peroxide in suspension and in the time of action on cultures of *Cl. welchii* presumably spore-free.

TABLE XIII

EFFECT OF VARIATIONS IN PERCENTAGE IN SUSPENSION AND IN TIME OF INCUBATION ON THE BACTERICIDAL ACTION OF ZINC PEROXIDE IN VITRO ON CLOSTRIDIUM WELCHII

Plate Colony Counts: 0.1 cc.–10^{-3} and 10^{-4} Tubes in Dilution Series
48-hr. Readings

Decimal Dilution	Est. No. of Bacteria at the Start	Per Cent ZnO_2	Time of Action				
			1 hr.	2 hrs.	4 hrs.	6 hrs.	24 hrs.
10^{-3}	880	Control p_H 8.2	++	++++	++++	++++	++++
		Control p_H 7.4	+++	++++	++++	++++	++++
		20	157	0	0	0	0
		10	+	0	0	0	0
		5	+	81	5	0	0
		1	+	96	23	0	0
		0.5	+	222	39	0	0
10^{-4}	88	Control p_H 8.2	165	291	+++	++++	++++
		Control p_H 7.4	244	411	++++	++++	++++
		20	9	0	0	0	0
		10	31	0	0	0	0
		5	53	5	0	0	0
		1	48	5	2	0	0
		0.5	52	18	2	0	0

The growth in the tubes of the decimal dilution series was in accord with the colony counts except for the presence of false negatives in the lower dilutions. The presence of viable bacilli, when the time of action was 24 hours, was further checked by transfers of 0.25 cc. from the tubes in the experimental set-up to tubes of 0.2 per cent dextrose cooked meat media plus 5 per cent of sheep's blood. No growth developed in any of the transfers from the zinc peroxide suspensions. Growth was abundant in the control transfers.

The results of 24 hours' contact with zinc peroxide will be given for the tests where the culture used as the inoculum contained spores only, or a mixture of spore and vegetating forms. We found that four to six hours' contact had little effect upon the spore forms. In some instances germination was delayed, but the final readings approximated the readings of the titrations made before zinc peroxide was added.

Table XIV shows that the vegetating forms of *Cl. welchii* are very sensitive to the bactericidal action of zinc peroxide *in vitro*, the spore forms less so. However, 24 hours' exposure to 20 or 10 per cent zinc peroxide regularly killed all the spores. Growth was usually absent in transfers from the 5 per cent suspensions, and only occasionally was a positive subculture obtained from the 1 and 0.5 per cent suspensions seeded with spores only, or a mixture of spore and vegetating forms. It would seem that the heated spores were more susceptible than the unheated spores. This may be due

to the fact, as other workers have found, that mixtures of spore and vegetating forms are harder to kill than spores alone, when antiseptics are employed.

TABLE XIV

ACTION OF ZINC PEROXIDE IN VITRO ON SPORES OF CLOSTRIDIUM WELCHII AND ON MIXTURES OF SPORE AND VEGETATING FORMS

Transfers: 0.1 cc. from Decimal Dilutions of Experimental Tubes into 0.2 Per Cent Dextrose Cooked Meat Medium
Readings after 6 Days' Anaerobic Incubation

Type Inoculum	Before Addition ZnO_2*	Time of Action	Control	Per Cent ZnO_2 in Medium				
				20	10	5	1	0.5
Heated†	10^{-3}	24 hrs.	10^{-6}	–	–	–	–	–
Unheated‡	10^{-4}	24 hrs.	10^{-7}	–	–	10^{-1}	–	–
Heated	10^{-1}	24 hrs.	10^{-7}	–	–	–	–	–
Unheated	10^{-4}	24 hrs.	10^{-7}	–	–	–	–	–
Heated	10^{-2}	24 hrs.	10^{-7}	–	–	–	–	10^{-1}
Unheated	10^{-5}	24 hrs.	10^{-8}	–	–	–	10^{-1}	10^{-2}

* Highest dilution giving positive subculture in transfers.
† Spore forms only.
‡ Mixture of spore and vegetative forms.

We observed no difference in the susceptibility of individual strains. The addition of whole blood or serum to the broth decreased the bactericidal action of zinc peroxide. When the number of viable organisms was determined after four hours' incubation in media containing blood or serum, the effect of the zinc peroxide was bacteriostatic only. After 24 hours' incubation, there was evidence of bactericidal action. Transfers from the 20, 10 and 5 per cent suspensions into cysteine broth failed to grow; transfers from the 1 and 0.5 per cent suspensions showed a significant decrease in the number of viable organisms when compared to the original inoculum. The plate colony counts were in accord with the results of the dilution series.

The influence of the number of organisms in the original inoculum on the final results of incubation in zinc peroxide suspensions was also determined. The colony counts from the platings of 0.2 cc. of the 10^{-2} tubes in the decimal dilution series in one such experiment are given in Table XV.

TABLE XV

EFFECT OF VARYING THE SIZE OF THE ORIGINAL INOCULUM ON THE BACTERICIDAL ACTION OF ZINC PEROXIDE IN VITRO ON CLOSTRIDIUM WELCHII

Plate Colony Counts: 0.2 cc.–10^{-2} Dilution of Experimental Tubes
72-hr. Readings

Original Inoculum	Time of Action	Culture Control	Per Cent ZnO_2 in Medium			
			5	1	0.5	0.1
1 cc.	3 hrs.	++++	200	+++	+++	+++
0.1 cc.	3 hrs.	++++	0	0	0	+
1 cc.	24 hrs.	++++	0	0	0	+
0.1 cc.	24 hrs.	++++	0	0	0	0
1 cc.	48 hrs.	++++	0	0	0	0
0.1 cc.	48 hrs.	++++	0	0	0	0

The number of organisms in the original inoculum has a direct effect upon the rapidity with which the zinc peroxide sterilizes the culture but not upon the final result.

The bactericidal action of filtrates from suspensions of zinc peroxide in infusion broth was also tested. One and 5 per cent suspensions of zinc peroxide in infusion broth were incubated for two hours at 37.5° C., then centrifuged and filtered through a Chamberland filter. The filtrates were tubed in 9.5 cc. amounts, seeded with 0.5 cc. of an 18-hour culture, presumably spore-free, and incubated for 48 hours. The number of viable organisms was determined after 24 and 48 hours. The distinct bactericidal action of these filtrates is well illustrated in Table XVI.

TABLE XVI

BACTERICIDAL ACTION OF FILTRATES OF 1 AND 5 PER CENT ZINC PEROXIDE SUSPENSIONS IN BROTH ON CLOSTRIDIUM WELCHII

	Increase in Turbidity	Plate Colony Counts—0.1 cc. Time of Action	
		24 hours	48 hours
Control p_H 7.6	++++	++++	+++
Control p_H 8.2	++++	++++	+++
Filtrate 1% p_H 7.8	—	5	0
Filtrate 5% p_H 8.1	—	0	0

Filtrates from different lots of zinc peroxide differed in their bactericidal activity. In the experiment reported above, zinc peroxide Lot No. 45 was used. In a similar experiment in which Lot No. 44 was used, the organisms multiplied in the 1 per cent filtrate, and the bactericidal action of the 5 per cent was not complete even after 48 hours' incubation. The filtrates from these two lots, Nos. 45 and 44, were tested for hydrogen peroxide with the potato-benzidine test, and it was found that the filtrates from Lot No. 45 gave a positive reaction through the 1:4 dilution, while that from Lot No. 44 was positive for peroxide in the undiluted filtrate only. This was additional evidence that the hydrogen peroxide in these filtrates played an important rôle in their bactericidal action.

In another experiment, the filtrates from 1 and 5 per cent suspensions of zinc peroxide Lot No. 42 were divided into two parts. One portion was boiled for 30 minutes and then cooled rapidly; the second portion was left unboiled. The boiled and unboiled filtrates were tubed in 9.5 cc. amounts and seeded with 0.5 cc. of an 18-hour culture of *Cl. welchii* in 1 per cent dextrose broth. Controls in boiled and unboiled broth were also set up. After 18 hours' incubation at 37.5° C., both control tubes and the boiled filtrates showed heavy growth, while the unboiled filtrates showed no visible increase in turbidity. One-tenth cubic centimeter from each of the six tubes was plated on blood agar. The colony counts from the control tubes and the boiled filtrates were too large to be estimated. No colonies developed on the plates made from the unboiled filtrates. Boiling the filtrates not only

destroyed the hydrogen peroxide, *i.e.*, tests for H_2O_2 were negative, but also expelled the free oxygen from the medium. The rôle of these two factors in the bactericidal action of zinc peroxide *in vitro* on *Cl. welchii* will be discussed later.

In Vivo Action of Zinc Peroxide on Clostridium Welchii.—We also tested the action of zinc peroxide *in vivo* on *Cl. welchii.* In preliminary experiments for the virulence of the test strain, injection of 0.25 cc. of an 18-hour culture of *Cl. welchii* in 1 per cent dextrose broth into the thigh muscles of guinea-pigs resulted in the rapid development of a gangrenous lesion followed by death of the animals within 18 hours.

Two sets of controls were included in this experiment: One for the virulence of the culture; the other for the effect of an intramuscular injection of a 5 per cent suspension of zinc peroxide in broth. All of the animals were injected intramuscularly into the thigh muscle of the right hind leg.

Three guinea-pigs received intramuscular injections of 0.25 cc. of an 18-hour culture of *Cl. welchii.* Two were injected with 0.5 cc. of a 5 per cent suspension of zinc peroxide in beef heart infusion broth. The experimental pigs were divided into two groups. In the first group, three pigs were given intramuscular injections of 0.25 cc. of the *Cl. welchii* culture to which 5 per cent zinc peroxide had been added immediately prior to injection. In the second group, three pigs were injected with 0.5 cc. of the same mixture.

The lesions in the control pigs injected with 0.25 cc. of the *Cl. welchii* culture developed rapidly. After four to six hours, the thigh had increased to three times its normal size. All pigs died within 18 hours. At autopsy, there was gas in the gangrenous muscle. The lesion extended up along the peritoneal wall. *Clostridium welchii* was recovered from the local lesions and from the heart's blood.

No lesion developed in any of the pigs injected with the mixture of *Cl. welchii* and zinc peroxide. The pigs were sacrificed one week after injection. At autopsy, there was a small aggregate of zinc peroxide in the muscle. There was no sign of any destruction of tissue or of any infectious process. The appearance of the muscle was the same as in the control pigs injected with the 5 per cent zinc peroxide suspension which were sacrificed at the same time as the experimental animals. Cultures made from the muscle area around the zinc peroxide particles were negative in five of the six experimental pigs. Cultures from one pig showed *Cl. welchii* and *E. coli communis.* The presence of the *E. coli* suggests the possibility that this positive culture for *Cl. welchii* may have been due to faulty technic at autopsy.

This experiment was repeated. The three pigs injected with 0.25 cc. of the *Cl. welchii* culture were all dead within 18 hours. The three pigs injected with 0.25 cc. of a 5 per cent suspension of zinc peroxide in the *Cl. welchii* cultures all survived. Two of the three pigs receiving 0.5 cc. of this mixture survived. One developed gangrene of the muscle and died within 24 hours after injection. The cultures of the muscle in the five pigs that survived

and were sacrificed ten days after injection were negative for *Cl. welchii*. A third experiment gave results similar to the first.

As a control for the viability of the organisms upon injection, tubes of dextrose meat media to which 5 per cent whole blood had been added were inoculated with 0.25 cc. of the same 5 per cent zinc peroxide-*Cl. welchii* suspension immediately after the injection of the pigs. Growth in the dextrose meat media was abundant after 24 hours' incubation.

We may conclude from this experiment that zinc peroxide in close contact with viable *Cl. welchii, in vivo,* is able to prevent the development of a gangrenous lesion. Factors other than the direct bactericidal action of zinc peroxide on the bacilli are probably involved, and these will be discussed later.

(B) *Clostridium Tetani.*—When *Cl. tetani* was the test organism, it proved necessary to incubate the experimental set-up under vaseline seals as growth in the control was unsatisfactory under aerobic conditions. Since *Cl. tetani* was not a prolific spore former, at times 48-hour cultures were used as the inoculum. The presence of false negatives in the decimal dilutions was checked by inoculating 0.2 per cent dextrose cooked meat media with 0.1 cc. from the tubes in the dilution series. Table XVII summarizes the results in some of the experiments made. Two stock strains were used. There was no significant difference in the susceptibility of these two strains.

TABLE XVII

ACTION OF ZINC PEROXIDE IN VITRO ON CLOSTRIDIUM TETANI

Transfers: 0.1 cc. From Decimal Dilutions of Experimental Tubes into 0.2 Per Cent Dextrose Cooked Meat Medium
Readings After Six to Ten Days' Anaerobic Incubation

Strain	Type Inoculum	Before Addition ZnO_2	Time of Action	Control	Per Cent Zinc Peroxide in Medium 20	10	5	1	0.5
No. 40 Exper. No. 1	Heated	10^{-2}	4 hrs.	10^{-2}	10^{-2}	10^{-2}	10^{-2}	10^{-2}	10^{-2}
	Unheated	10^{-4}	4 hrs.	10^{-4}	10^{-1}	10^{-2}	10^{-2}	10^{-2}	10^{-3}
	Heated	10^{-2}	24 hrs.	10^{-6}	–	–	–	–	10^{-1}
	Unheated	10^{-4}	24 hrs.	10^{-7}	–	–	–	10^{-1}	10^{-1}
No. 40 Exper. No. 2	Heated	10^{-4}	4 hrs.	10^{-4}	10^{-3}	10^{-3}	10^{-4}	10^{-4}	10^{-4}
	Unheated	10^{-5}	4 hrs.	10^{-6}	10^{-3}	10^{-4}	10^{-4}	10^{-4}	10^{-4}
	Heated	10^{-4}	24 hrs.	10^{-6}	–	–	10^{-1}	10^{-1}	10^{-1}
	Unheated	10^{-5}	24 hrs.	10^{-7}	10^{-1}	10^{-2}	10^{-1}	10^{-1}	10^{-2}
No. 41 Exper. No. 1	Heated	10^{-1}	4 hrs.	10^{-1}	10^{-1}	10^{-1}	10^{-1}	10^{-1}	10^{-1}
	Unheated	10^{-4}	4 hrs.	10^{-5}	10^{-1}	10^{-1}	10^{-1}	10^{-2}	10^{-3}
	Heated	10^{-1}	24 hrs.	10^{-4}	–	–	–	–	–
	Unheated	10^{-4}	24 hrs.	10^{-7}	–	–	–	–	–
No. 41 Exper. No. 2	Heated	10^{-3}	4 hrs.	10^{-4}	10^{-3}	10^{-2}	10^{-3}	10^{-3}	10^{-3}
	Unheated	10^{-4}	4 hrs.	10^{-5}	10^{-3}	10^{-3}	10^{-3}	10^{-4}	10^{-4}
	Heated	10^{-3}	24 hrs.	10^{-7}	–	–	10^{-1}	10^{-2}	10^{-2}
	Unheated	10^{-4}	24 hrs.	10^{-7}	–	–	10^{-1}	10^{-2}	10^{-2}

Note: Heated inoculum, spore forms only.
Unheated inoculum, mixture of spore and vegetating forms.

An analysis of these results shows that the number of viable forms after four hours' action by zinc peroxide approximates the number of spores in the original inoculum. From this we conclude that few vegetative forms survive after this period of contact in the 20, 10 and 5 per cent suspensions. Some vegetative forms may be viable in the 1 and 0.5 per cent suspensions. The spores themselves are not killed by four hours' contact, although their reproductive capacity is injured as the time of germination is increased. After 24 hours' contact, in only one instance did any of the spores survive in the 20 and 10 per cent suspensions. The number was greatly reduced in the 5, 1 and 0.5 per cent suspensions. At times, no growth was present in the transfers from such suspensions. When the time of action was 48 hours or longer, there were no positive subcultures from the 20, 10 and 5 per cent suspensions, and growth occurred only sporadically from the 1 and 0.5 per cent suspensions.

TABLE XVIII

BACTERICIDAL ACTION OF ZINC PEROXIDE IN VITRO ON CLOSTRIDIUM HISTOLYTICUM AND CLOSTRIDIUM SPOROGENES, MIXTURE OF SPORE AND VEGETATING FORMS

Plate Colony Counts: 0.1 cc.–10^{-3} Dilution of Experimental Tubes
96-hr. Readings

Organism	Est. No. of Bacteria at the Start	Time of Action	Culture Control	Per Cent Zinc Peroxide in Medium 20	10	5	1	0.5
Clostridium histolyticum								
(1) Heated	10							
(2) Unheated	950	4 hrs.	+	10	25	38	57	52
		24 hrs.	+++	11	10	12	9	14
		48 hrs.	++++	0	0	3	4	0*
(1) Heated	77	24 hrs.	++++	82	65	78	91	85
		48 hrs.	++++	0	0	0*	0*	0*
		96 hrs.	+++	0	0	0	0*	0
Clostridium sporogenes								
(1) Heated	7							
(2) Unheated	670	4 hrs.	+++	3	21	42	51	62
		24 hrs.	++++	5	3	6	5	7
(1) Heated	41							
(2) Unheated	1190	4 hrs.	+++	43	39	57	93	125
		24 hrs.	++++	31	29	45	39	44
		48 hrs.	++++	0*	0*	0*	17	9
		72 hrs.	+++	0	0	0	0*	0*

(1) Heated—spore forms only.
(2) Unheated—mixture of spore and vegetating forms.
* Negative in this dilution, but growth in direct transfers (0.1 cc. into each of five tubes) from experimental tubes into 0.2 per cent dextrose cooked meat medium.

(C) *Clostridium Histolyticum, Cl. Sporogenes, Cl. Novyi, Cl. Sordellii, and Cl. Œdematis Maligni.*—The technic of determining the action of zinc peroxide *in vitro* on these clostridia was the same as on *Cl. tetani*, except that plate colony counts were made in some of the tests on *Cl. histolyticum* and *Cl. sporogenes*. Our results are summarized in Tables XVIII and XIX.

An analysis of Table XVIII shows that the total number of viable forms is greatly decreased after four hours' contact with zinc peroxide. When

the time of action is 24 hours, the number of viable forms is approximately the same as the number of spore forms in the original inoculum. After 48 hours' contact, the number of viable spores is greatly reduced. Incubation for more than 48 hours in 20, 10 or 5 per cent zinc peroxide suspensions results in absence of growth when transfers are made to fresh media.

TABLE XIX

BACTERICIDAL ACTION OF ZINC PEROXIDE IN VITRO ON CLOSTRIDIUM HISTOLYTICUM, SPOROGENES, NOVYI, SORDELLII AND ŒDEMATIS MALIGNI

Transfers: 0.1 cc.–Decimal Dilutions of Experimental Tubes into 0.2 Per Cent Dextrose Cooked Meat Medium
Six- to Ten-Day Readings

Organism	Before Addition ZnO_2*	Time of Action	Control	Per Cent Zinc Peroxide in Medium 20	10	5	1
Cl. histolyticum							
Heated†	10^{-2}	24 hrs.	10^{-7}	10^{-2}	10^{-1}	10^{-1}	10^{-2}
Unheated‡	10^{-6}	24 hrs.	10^{-8}	10^{-1}	10^{-1}	10^{-2}	10^{-2}
Cl. sporogenes							
Heated	10^{-3}	24 hrs.	10^{-6}	10^{-2}	10^{-3}	10^{-3}	10^{-3}
Unheated	10^{-6}	24 hrs.	10^{-8}	10^{-3}	10^{-2}	10^{-2}	10^{-3}
Cl. novyi							
Heated	10^{-2}	24 hrs.	10^{-7}	10^{-1}	10^{-1}	10^{-2}	10^{-2}
Unheated	10^{-5}	24 hrs.	10^{-8}	10^{-1}	–	10^{-1}	10^{-2}
Cl. sordellii							
Heated	10^{-1}	24 hrs.	10^{-5}	10^{-1}	10^{-1}	10^{-1}	10^{-1}
Unheated	10^{-5}	24 hrs.	10^{-7}	10^{-1}	10^{-1}	10^{-1}	10^{-1}
Cl. œdematis mal.							
Heated	10^{-2}	24 hrs.	10^{-7}	10^{-1}	10^{-2}	10^{-3}	10^{-2}
Unheated	10^{-5}	24 hrs.	10^{-7}	10^{-2}	10^{-2}	10^{-2}	10^{-2}

* Highest dilution showing growth in transfers.
† Spore forms only.
‡ Mixture spore and vegetating forms.

Table XIX does not give a complete picture of the results since the final reading of the controls was usually reached after 48 hours' incubation at 37.5° C. while the transfers from the zinc peroxide suspensions were rarely positive within 48 hours. At times, from four to six days' incubation was necessary for the germination of the spores, especially in the dilutions where they were few in number. When the time of action of the zinc peroxide was 48 hours, the number of viable spore forms was always reduced. When the seeded suspensions were incubated for 72 or 96 hours, there were rarely viable spores in the 20 or 10 per cent suspensions. Positive subcultures were occasionally obtained from the 5- and 1-per cent suspensions. At times some spores were completely resistant and survived seven to ten days' incubation in the zinc peroxide suspensions. The spores of *Cl. œdematis maligni* were on the whole the most resistant of those tested.

Size of Inoculum.—Using *Cl. histolyticum* and *Cl. sporogenes* as the test organisms, we determined the effect of varying the size of the inoculum on the bactericidal action of zinc peroxide *in vitro*. The inocula used were 1.0, 0.5, 0.05, and 0.005 cc. of an 18-hour broth culture. The number of viable forms after 24 hours' incubation of the seeded zinc peroxide suspensions

depended upon the number of spores in the original inoculum rather than the total viable forms.

SUMMARY.—From an analysis of the results of the experiments made upon the anaerobic spore-bearing clostridia, we conclude that the vegetating forms are very sensitive to the bactericidal action of zinc peroxide *in vitro*, the spore forms less susceptible. The spores of *Cl. welchii* and *Cl. tetani* were more sensitive than those of the other clostridia in this group. The reproductive capacity of all spores is injured, however, even after four hours' contact with zinc peroxide as germination is delayed when transfers to fresh media are made.

GROUP IV.—Anaerobic Nonspore-Forming Bacteria: The anaerobic and micro-aerophile hemolytic streptococci have been considered in the section on hemolytic streptococci.

The strains of anaerobic nonhemolytic streptococci tested were isolated from acute and chronic wound infections and lung abscesses. The micro-aerophilic nonhemolytic streptococci were recovered from synergistic gangrenes of the chest or abdominal wall, from wound infections and from lung abscesses. Two strains of *B. fusiformis* were tested, one from a lung abscess, the other from a fusospirochetal infection of the mouth. The strain of *B. necrophorus* was isolated from an ileostomy opening in a patient with ulcerative colitis.

It was possible to test only the micro-aerophilic nonhemolytic streptococci under the usual experimental conditions. Special technic was necessary with the other organisms in this group. No attempt was made to estimate the number of viable organisms present before the addition of zinc peroxide since we found that the results of decimal dilutions or plate colony counts were too inconsistent to permit of any degree of accuracy in such determinations.

When the anaerobic nonhemolytic streptococcus was the test organism, the zinc peroxide was added directly to 24- or 48-hour cultures of the streptococcus in 1 per cent dextrose broth. Some strains grew well under anaerobic conditions within 24 hours, other strains required 48 hours' incubation before sufficient growth developed to permit experimentation. Several cultures were pooled and then redivided in 10 cc. amounts to insure approximately the same number of organisms in each of the tubes of the experimental set-up.

Since *B. fusiformis* and *B. necrophorus* grew poorly in liquid media in the absence of body fluids, the test suspensions were prepared from broth washings of blood agar slants. The washings from six to eight slants were pooled, diluted to the required amount with broth, and 10 cc. of the suspensions pipetted into each of the experimental tubes.

The presence or absence of viable organisms after the addition of zinc peroxide was ascertained by platings of 0.2 cc. of the tubes in the experimental set-up on blood agar and by direct transfers of 0.5 cc. into 0.2 per cent dextrose cooked meat media. The results of the experiments made on this group of organisms are summarized in Tables XX and XXI.

TABLE XX

EFFECT OF VARIATIONS IN PERCENTAGE OF ZINC PEROXIDE IN SUSPENSION ON ITS BACTERICIDAL ACTION IN VITRO ON ANAEROBIC NONSPORE-FORMING BACTERIA

Platings: 0.2 cc.–Experimental Set-Up
Transfers: 0.5 cc. From Experimental Tubes into 0.2 Per Cent Dextrose Cooked Meat Medium
96-hr. Readings

Strain	Time of Action	Culture Control	Per Cent Zinc Peroxide 20	10	5	1	0.5
Anaerobic nonhem. strep.	4 hrs.	+	−	−	−	+*	+
	24 hrs.	+	−	−	−	−	−
Micro-aero. nonhem. strep.	4 hrs.	+	−	−	−	±†	+
	24 hrs.	+	−	−	−	−	−
B. fusiformis	4 hrs.	+	−	−	−	+	+
	24 hrs.	+	−	−	−	−	−
B. necrophorus	4 hrs.	+	−	−	−	+	+
	24 hrs.	+	−	−	−	−	−

* No growth in two out of five strains tested.
† No growth in two out of six strains tested.

TABLE XXI

EFFECT OF TIME OF ACTION OF 1 PER CENT ZINC PEROXIDE IN SEEDED SUSPENSIONS OF ANAEROBIC NONSPORE-FORMING BACTERIA

Transfers: 0.5 cc. from Experimental Tubes into 0.2 Per Cent Dextrose Cooked Meat Medium

Strain	Control Cultures Time of Action 2 hrs.	4 hrs.	6 hrs.	18 hrs.	One Per Cent Zinc Peroxide Time of Action 2 hrs.	4 hrs.	6 hrs.	18 hrs.
Anaerobic nonhem. strep.								
R	+	+	+	+	+	+	−	−
C	+	+	+	+	+	+	−	−
S	+	+	+	+	−	−	−	−
M	+	+	+	+	+	−	−	−
H	+	+	+	+	+	+	−	−
Micro-aero. nonhem. strep.								
R	+	+	+	+	+	−	−	−
F	+	+	+	+	+	+	−	−
Q	+	+	+	+	+	+	−	−
B.I	+	+	+	+	+	+	+	−
B. necrophorus								
L	+	+	+	+	+	+	−	−
B. fusiformis								
O	+	+	+	+	+	+	−	−
R	+	+	+	+	+	+	+	−

This group of anaerobic nonspore-forming bacteria proved sensitive to the bactericidal action of zinc peroxide *in vitro*. As in the other groups of organisms tested, there was a direct relationship between the percentage of zinc peroxide in suspension and the time of action required to sterilize the cultures. The anaerobic and micro-aerophilic nonhemolytic streptococci did not seem to be quite as susceptible as the anaerobic and micro-aerophilic hemolytic streptococci. Addition of body fluids to the seeded zinc peroxide suspensions increased the time of action necessary for negative subcultures.

Effect of Zinc Peroxide in Vitro on Streptococcus and Clostridium Welchii Hemotoxin.—In one experiment, in which we were testing the effect of the addition of zinc peroxide to 24-hour cultures of hemolytic streptococcus in the presence of body fluids, 5 per cent of whole blood was added to the experimental and control tubes. After two hours' incubation at 37.5° C., there was no sign of hemolysis in the zinc peroxide suspensions, while the control tubes were port wine in color. This led us to suspect that zinc peroxide destroys hemotoxin *in vitro.*

The streptococcus hemotoxin was prepared according to De Kruif's[13] method. Tubes containing 30 cc. of beef heart infusion broth plus 25 per cent inactivated horse serum were seeded with 1 cc. of a six-hour culture of hemolytic streptococcus. The cultures were then incubated for eight hours at 37.5° C., centrifuged and filtered through a Chamberland filter.

Clostridium welchii hemotoxin was prepared by inoculating 30 cc. tubes of boiled 1 per cent proteose peptone broth with 1 cc. of an 18-hour culture in 1 per cent dextrose broth. The tubes were incubated anaerobically for 16 hours, then centrifuged for 15 minutes and the supernatant fluid filtered through a Chamberland filter. This filtration was found to reduce the titer of the toxin but we wished to eliminate the possibility of living organisms multiplying in the control tubes.

The titer of the toxin was determined by adding to 1 cc. of progressive dilutions of the toxin in normal saline 0.5 cc. of a 2.5 per cent suspension of sheep's washed red cells in saline. The series was then incubated at 37.5° C. in a water bath, and if, after 30 minutes' incubation, hemolysis was complete through 1:16, the experiment was set up.

The toxin was divided into 10 cc. amounts. One tube served as a control for loss of titer under experimental conditions. Twenty, ten, five and one per cent suspensions of zinc peroxide were made. The time of action was one, two, three, four and twelve or eighteen hours. In experiments lasting more than four hours, the tubes were sealed with vaseline to prevent spontaneous deterioration of the toxin due to contact with the air. We realized that zinc peroxide would be more effective at 37.5° C. than at room temperature, but found that the titer of the streptococcus toxin decreased rapidly at this temperature. The tests with *Cl. welchii* hemotoxin were carried out at both room and incubator temperatures. Experiments were set in duplicate, triplicate or quadruplicate as conditions required. After the desired time of action, all tubes including the controls were centrifuged for ten minutes and the supernatant fluid tested for toxin titer as previously described. Readings were made after 30 minutes', one and two hours' incubation. The tubes were then transferred to the ice-box and final readings made the next day. Table XXII gives the results in some of the tests made.

The end-points of the titrations given above do not represent complete hemolysis, but the dilution in which there was some visible lysis of the red cells. For this reason they do not give a picture of the difference in rate

of lysis of the red cells by the control toxin and the supernatants from the zinc peroxide-toxin suspensions. Table XXIII illustrates this point.

TABLE XXII

EFFECT OF ZINC PEROXIDE IN VITRO ON STREPTOCOCCUS AND CLOSTRIDIUM WELCHII HEMOTOXIN

Hemotoxin	Original Titer	Temp. Expt.	Time of Action	Control Titer	Titer Toxin + ZnO_2 20%	10%	5%	1%
S. hemolyticus	1:128	23° C.	1 hr.	1:128	0	0	1:8	1:32
			2 hrs.	1:128	0	0	1	1:16
			3 hrs.	1:64	0	0	1	1:8
S. hemolyticus	1:128	23° C.	4 hrs.	1:128	0	0	1	1:16
			12 hrs.	1:128	0	0	0	0
Cl. welchii	1:256	22.6° C.	1 hr.	1:256	0	0	1:32	1:64
			2 hrs.	1:256	0	0	1:16	1:64
			4 hrs.	1:128	0	0	1:4	1:32
			18 hrs.	1:128	0	0	0	0
Cl. welchii	1:256	37.5° C.	2 hrs.	1:128	0	0	1:2	1:4
			4 hrs.	1:128	0	0	1	1
			12 hrs.	1:128	0	0	0	0

TABLE XXIII

TITER OF STREPTOCOCCUS HEMOTOXIN PLUS ZINC PEROXIDE

Time of Action: Three Hours at 23° C. Readings after 30 Minutes, One and Two Hours' Incubation in Water Bath at 37.5° C. of Control Toxin and Supernatants from Toxin-Zinc Peroxide Suspensions

Titer	1	1:2	1:4	1:8	1:16	1:32	1:64
Control toxin							
30-min. readings	++++	++++	++++	++++	++	−	−
1-hr. readings	++++	++++	++++	++++	+++	++	+
2-hr. readings	++++	++++	++++	++++	++++	+++	++
Toxin plus 20% ZnO_2							
30-min. readings	−	−	−	−	−	−	−
1-hr. readings	−	−	−	−	−	−	−
2-hr. readings	−	−	−	−	−	−	−
Toxin plus 10% ZnO_2							
30-min. readings	−	−	−	−	−	−	−
1-hr. readings	−	−	−	−	−	−	−
2-hr. readings	−	−	−	−	−	−	−
Toxin plus 5% ZnO_2							
30-min. readings	−	−	−	−	−	−	−
1-hr. readings	−	−	−	−	−	−	−
2-hr. readings	+	−	−	−	−	−	−
Toxin plus 1% ZnO_2							
30-min. readings	−	−	−	−	−	−	−
1-hr. readings	+	−	−	−	−	−	−
2-hr. readings	++++	+++	+++	+	−	−	−

The same difference in rapidity and completeness of hemolysis was noted with *Cl. welchii* hemotoxin. It is probable that this ability of zinc peroxide to inactivate or destroy hemotoxin plays an important part in its action *in vivo*, and may account for the rapid improvement in the clinical appearance

of the lesion, and the general condition of the patient. Experiments now in progress indicate that zinc peroxide also removes fibrinolysin from cultures of hemolytic streptococci.

Discussion and Probable Explanation of the Antiseptic Action of Zinc Peroxide in Vitro.—An analysis of the data obtained from our experiments shows that the organisms tested fall into two groups: Those sensitive to the bactericidal action of zinc peroxide *in vitro*, namely, the anaerobic and micro-aerophilic organisms, aerobic hemolytic streptococcus and pneumococcus; and those relatively insusceptible—staphylococcus, *streptococcus viridans*, *E. coli*, *B. pyocyaneus* and *B. proteus*. This difference in sensitivity would seem to depend not only upon the intolerance or tolerance of free oxygen in the environment, but also upon the absence or presence of catalase in the cell, with the resultant sensitivity to the toxic action of hydrogen peroxide in the medium. In addition to controlling the effect of the increased oxygen tension in the zinc peroxide suspensions, and the hydrogen peroxide in the supernatant broth of such suspensions, we also determined the effect of the addition to the medium of zinc salts in general.

The increased oxygen tension in zinc peroxide suspensions would inhibit the multiplication of anaerobic and micro-aerophilic organisms[14, 15] but, of itself, would not account for the distinct bactericidal action of zinc peroxide, especially when the time of action is comparatively short, *i.e.*, one to four hours. We found that there was no appreciable increase or decrease in the viable count after four to six hours' oxygenation at 37.5° C. of *Cl. welchii* cultures. After 24 hours' oxygenation, there was a decided decrease in the number of viable organisms, but the cultures had not been sterilized. However, the effect of a high oxygen tension in the zinc peroxide suspensions cannot be disregarded. This is brought out by the following experiment in which broth cultures of *Cl. welchii*, to which 0.0003 per cent reagent hydrogen peroxide had been added, were oxygenated during incubation. The combined effect of the oxygen and hydrogen peroxide resulted in a great decrease in the viable count after four hours, even though there was no decrease in the oxygenated control, and no decrease, and even, in some cases, an increase in the control containing the hydrogen peroxide. We feel that the bactericidal action of zinc peroxide *in vitro* on the anaerobic and micro-aerophilic organisms may possibly be explained by the combined action of the free oxygen liberated by the zinc peroxide in suspension, and the hydrogen peroxide in the supernatant broth of such suspensions, when the concentration of the hydrogen peroxide is in itself sublethal. It is important to take into consideration that the concentration of hydrogen peroxide in the zinc peroxide suspensions remains at a constant level, whereas, if dilutions of reagent hydrogen peroxide are used, this concentration decreases as the period of incubation increases, and may fall below the bacteriostatic or bactericidal level.

The work of McLeod and Gordon,[16, 17] Avery and Morgan,[18] and Todd[19] has shown that incubation in oxygen-rich media may result in the sterilization of cultures of hemolytic streptococci and pneumococci within a relatively

short time due to the rapid accumulation of hydrogen peroxide in the aerated media. However, since this bacterial hydrogen peroxide is not formed until the logarithmic growth phase is well established, it can play no part in the bactericidal action of zinc peroxide *in vitro*, as we have not observed multiplication of these species in zinc peroxide suspensions. The concentration of hydrogen peroxide in the broth supernatants of zinc peroxide suspensions is not in itself sufficient to account for the antiseptic action of zinc peroxide on aerobic hemolytic streptococci and pneumococci. We found, however, that it was sufficient to account for an inhibition of multiplication and, in some cases, for the death of a large proportion of the cocci.

The combined effect of an increased oxygen tension and low concentrations of reagent hydrogen peroxide (0.0009 to 0.0018 per cent) on aerobic hemolytic streptococcus was also determined. The oxygenation of the medium increased slightly the antiseptic action of the hydrogen peroxide. We also added 1 per cent zinc oxide and 0.0009 per cent hydrogen peroxide to broth cultures of aerobic hemolytic streptococcus, which were then oxygenated for four hours at 37.5° C. Although the viable count was reduced approximately 50 per cent after the four-hour incubation period, the combined effect of these three agents did not equal the effect of 1 or 0.5 per cent zinc peroxide on these organisms. Factors, other than these three, must be involved in the mechanisms of the action of zinc peroxide *in vitro* on aerobic hemolytic streptococcus. Zinc peroxide is not without effect on the broth medium itself, as Kjedahl tests on the supernatants from 20 and 10 per cent zinc peroxide suspensions in broth show 65 per cent less protein after 24 hours' incubation at 37.5° C. The supernatant broth becomes colorless. This undoubtedly alters the nutritive properties of the medium and may increase the antiseptic action of the zinc peroxide. We cannot exclude the possibility of a direct oxidizing action of "active oxygen" on the protoplasm of the bacterial cell, or, as Broh-Kahn and Mirsky[20] suggest, a direct combination of oxygen with cellular enzymes. At the present time, however, we have no experimental data to prove such assumptions.

Miller,[21] in 1889, was the first to attribute bactericidal properties to metals. Behring[22] confirmed his observations and tested the germicidal properties of various metals and their salts. He found that zinc had a slight antiseptic action. We determined the effect of addition of zinc oxide to broth cultures since this compound is present as such in the commercial zinc peroxide and probably represents the end-product of the decomposition of zinc peroxide in broth suspensions. Zinc oxide had a slow bactericidal action on hemolytic streptococci and pneumococci, but there was no evidence of a germicidal action within the period required for almost complete sterilization of the cultures by zinc peroxide, *i.e.*, four to six hours. We observed no significant bacteriostatic or bactericidal effect on *Cl. welchii, staphylococcus aureus* or *E. coli* under our experimental conditions. We also tested the action of zinc peroxide heated in an electric furnace to decompose the peroxide. The effect of this heated material was comparable to that of zinc oxide.

Filtrates from 1 and 5 per cent suspensions of zinc oxide in broth had no effect on the multiplication of *Cl. welchii*. When hemolytic streptococcus was the test organism, the lag-period was increased and the rate of multiplication less rapid. Viable counts made after 24 hours' incubation showed that the number of organisms in these filtrates was from one-half to one-third the number in the controls.

We have shown that the hemotoxin of streptococci and *Cl. welchii* is destroyed or inactivated by zinc peroxide *in vitro*. This property must play an important rôle *in vivo*. Zinc peroxide also oxidizes or adsorbs the products of bacterial metabolism, as cultures are deodorized rapidly if zinc peroxide is added. Infected wounds, such as fusospirochetal abscesses, also lose their characteristic odor when treated with zinc peroxide.

Although we are not attempting any correlation of the mechanisms of the action of zinc peroxide *in vitro* and *in vivo*, we have found that the organisms sensitive to its bactericidal action *in vitro* are the ones which tend to disappear rapidly from infected lesions treated with zinc peroxide.

CONCLUSIONS

The antiseptic action of zinc peroxide *in vitro* has been determined on certain aerobic, anaerobic and micro-aerophilic organisms commonly found in surgical infections.

We have taken as our criterion of sensitivity, a marked reduction in the viable count after four hours' incubation at 37.5° C. of seeded broth suspensions of zinc peroxide, and sterilization of the suspensions within 24 hours.

On this basis, we have classed the following organisms as sensitive to the bactericidal action of zinc peroxide *in vitro*: Hemolytic streptococci—aerobic, anaerobic and micro-aerophilic; pneumococci; the vegetative forms of the anaerobic spore-bearing bacilli—*Cl. welchii, Cl. tetani, Cl. histolyticum, Cl. sporogenes, Cl. novyi, Cl. sordellii* and *Cl. œdematis maligni*; the anaerobic nonspore-forming bacteria—nonhemolytic streptococci, both anaerobic and micro-aerophilic, *B. fusiformis* and *B. necrophorus*.

The organisms which proved to be relatively resistant were: *Streptococcus viridans, staphylococcus aureus, E. coli, B. proteus and B. pyocyaneus.*

The spores of the anaerobic spore-bearing clostridia were also relatively insensitive. Of the species tested, the spores of *Cl. welchii* and *Cl. tetani* were more suspectible than those of the other bacilli in this group.

The hemotoxins of streptococcus and *Cl. welchii* are destroyed or inactivated by zinc peroxide *in vitro*.

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BENIGN AND MALIGNANT LESIONS OF THE MALE BREAST

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LESIONS of the male breast are reported infrequently enough to justify the presentation of this series of cases. Many members of the medical profession tend to regard a male breast lesion as an oddity rather than as a condition of pathologic or therapeutic significance. Diseases of the male breast have been exceeded in number by those in the female to such extent that they have been underestimated and are often unmentioned in our text-books. The literature on lesions of the male breast is voluminous, but careful studies of the subject as a whole are scant. Since so many malignancies are reported, one would assume that any breast swelling must be cancerous. Recently, however, more authors have recognized the relative infrequency of malignancies in the male breast as compared with the larger number of benign and nonneoplastic lesions.

Anatomy.—Many of the descriptions give an erroneous impression of the anatomy of the male mammary gland. Gray and Spalteholz state that it contains only rudiments of gland structure. Other anatomic works do not even mention the male breast, and one is left with the impression that the male breast contains only small portions of the gland tissue in a very atrophied and nonfunctioning condition. Cooper made one of the first complete reports showing that tumors of the male breast contained all of the elements of the female breast and varied from it only in degree. More recently Andrews[1] has called attention to the fact that the male breast is an exceedingly complicated system of open ducts and gland tissue, far from vestigial in nature. He made serial sections of a number of breasts of boys and men of all ages. In this study he found that the breast tissue of the adult male persists in essentially the same state as that in the preadolescent female, and nearly as much glandular tissue which is present in an adolescent boy will remain in later life. The ducts are patent and each has an opening through the outer skin at the nipple. An adolescent boy's breast shows a structure quite comparable with that of a girl of ten years of age.

Etiology.—The chief etiologic factors which produce swelling of the male breast are trauma, infection, associated endocrine disturbances, particularly of the sex glands, and neoplasms. As may be noted in Table III the percentage of cases in this report giving a history of injury is quite small. Considering the many types of injury and chronic irritation that do occur to the male breast, it would seem that the element of trauma plays a very uncertain rôle in the causation of these lesions. The element of infection is of much greater significance than trauma, as mastitis is the most common lesion of the male breast. The anatomic investigations mentioned above show that there is an excellent possibility for entrance of infection from without. The histories in this series of

cases would indicate that infection plays an important etiologic rôle. Most authors refer to mastitis in the male breast as adolescent mastitis. Whereas this condition usually occurs during adolescence, it is by no means entirely confined to this period of life, as many cases show this condition at all ages. Endocrine disturbances do have some part in the etiology of swelling of the male breast, as may be noted in Table IV. The exact significance of this factor, however, has not been definitely determined.

True hypertrophy of the male breast, termed gynecomastia, is the homologue of virginal hypertrophy in the female. Slight and transient enlargement of the breast at puberty is a normal occurrence in a definite number of males, according to Jung and Shafton.[5] Diffuse enlargement of one or both breasts may be present and this condition may persist, either at puberty or with the decline of sexual life. Geschickter[3] states that this benign enlargement, as in infantile or virginal hypertrophy in the female, is the result of increase in the length of ducts and in periductal connective tissue. Lewis and Geschickter[6] report that clinical observations indicate a definite relationship between the sex organs and gynecomastia. In hermaphrodites enlargement of the male breast is also observed. This condition occurs in 5 per cent of the cases of chorionic epithelioma and teratoma of the testis, according to Ferguson.[2] In boys or young adults, atrophy or excision of one testicle with hypertrophy of the interstitial cells of the other testicle may lead to enlargement of the breasts. Testicular tumors containing chorionic tissue secrete both prolan, the pituitary-like sex hormone, and estrin, the female sex hormone. In male monkeys and in man, injections of estrin will produce gynecomastia. Breast enlargement in the male is usually benign and self-limited. Spontaneous regression may occur, though if this condition is once established, it does not respond to endocrine treatment. Excision of the mammary gland in gynecomastia is indicated primarily for cosmetic reasons.

The smaller number of breast diseases and neoplasms in man can be explained, in part, by the arrest in its anatomic development about the age of puberty and by the absence of the functional activity which is normally present in the female breast.

Incidence and Types of Lesions.—Neal[8, 9] has made a very complete report of a large number of male and female breast lesions. Of 9,279 breasts examined, 308 (3.3 per cent) lesions were in the male, giving a ratio of one male to 29 female breast lesions. He found that the most frequent diseases of the male breast were nonneoplastic in nature—143 of his total of 308 cases (46.4 per cent). The second most common lesions were benign tumors—105 (34 per cent). Third in frequency were carcinomata—50 (16.3 per cent). Of these, carcinomatous neoplasms of skin origin accounted for 16 per cent, and those of duct or acinus origin, for 84 per cent. There were 10 cases of sarcoma, a percentage of 3.25.

Tables I and II show that there were 41 male breast lesions in this series, with an incidence of one male breast lesion to 23 in the female. These percentages of various pathologic conditions in the male breast are similar to those in

TABLE I

RATIO OF SEX INCIDENCE OF BREAST LESIONS OCCURRING AT ST. ELIZABETH'S HOSPITAL, RICHMOND, VA.

Total breast lesions (through November 15, 1938)..... 985
Male..... 41
Female..... 944
Ratio 1 male to 23 female breast lesions

TABLE II

DIAGNOSES

Chronic cystic mastitis:
23 male (1 associated with a fissure of nipple)
332 female
Abscess:
20 female
Benign tumors:
7 male
215 female
Malignant tumors:

Carcinoma	4 male	1 adenocarcinoma, Grade 3	
		1 papillary cystadenocarcinoma, Grade 2	
		1 squamous cell carcinoma, Grade 3	
		1 metastatic chorionic epithelioma from testis	
	359 female		Total female 365
Sarcoma	6 female		

Supernumerary nipple and breast:
5 male
9 female
Hypertrophy, simple:
2 male
3 female

TABLE III

MALE BREAST LESIONS

Age of patient:
Youngest—13 years (3)
Oldest—73 years
Average age—38½ years
Left breast—23
Right breast—18
Injury history—6
No injury history—35
Duration:
Shortest—2 weeks
Longest—5 years
Average—5 months

Neal's report, except that in our report what might be termed congenital deformities, such as accessory nipples and breast tissue, are included, and there were no cases of sarcoma in our group of patients. It will be noted from

Table II that in the female, the most common breast lessions were malignant tumors; the second in frequency were mastitis and other nonneoplastic conditions; and the third were benign tumors. Lesions of the male breast constitute from 3 to 5 per cent of all the breast diseases which afflict both sexes. The mammary gland in man may be the site of any of the diseases that are found in the female, and the microscopic appearance is almost identical with similar diseases more commonly found in the female organ.

TABLE IV

INCIDENCE OF ASSOCIATED PATHOLOGY

Associated endocrine pathology:
7 breast lesions:
1—atrophy of left testis
1—hypertrophy of prostate with transurethral resection
2—achondrodystrophy
2—bilateral undescended testicle associated with hermaphroditism (?)
1—chorionic epithelioma of testis
Associated general pathology:
1 recently healed pulmonary tuberculosis
2 cerebrospinal syphilis treated—Wassermann negative

Treatment and Results.—The indications for, and type of, treatment in male breast lesions are the same as the well-recognized treatment for similar female conditions. Little, if any, satisfactory results can be obtained by endocrine therapy in nonneoplastic conditions in the male. If the neoplasm, or suspected neoplasm, is small, the whole tumor should be excised and examined immediately. When the tumor is extensive, a biopsy should be obtained, and if fresh frozen microscopic sections show a benign process, simple excision of the tumor or the breast is indicated. If malignancy is found, an immediate radical breast operation should be performed with or without roentgenotherapy, according to the usual technic for a similar condition in a female. Table V summarizes the type of treatment and Table VI gives the results in our series of patients. Even though the number of lesions is small, these results seem distinctly better than a corresponding number of cases in the female.

TABLE V

TREATMENT

41 male lesions:
30 operative lesions (no mortality):
1—radical breast operation
17—simple mastectomy including nipple
6—simple mastectomy leaving nipple (Warren type)
5—excision of breast tumor
1—biopsy and excision of sloughs; irradiation
11 nonoperative lesions:
5—supernumerary nipple and breast—no treatment
3—mild bilateral mastitis of short duration in adolescent boys—palliative treatment
2—subacute mastitis relieved by local treatment
1—metastasis to breast from carcinoma of testis—palliative and attempted irradiation

TABLE VI

RESULTS

37 benign lesions:
All well (1 improving under treatment). No recurrence
4 malignancies:
1—radical operation performed; patient well 7 years and 3 months later
1—simple mastectomy, including pectoral fascia; well 16 years
1—biopsy; irradiation; well 4 years
1—metastasis from chorionic epithelioma of testis; dead

CASE REPORTS

Case 1.—*Gynecomastia:* The patient, a male, age 25, was admitted to the hospital complaining of bilateral undescended testicles. He had been operated upon elsewhere at the age of 12, at which time one testicle was found to be atrophied and the second partially so. Since that operation, the secondary sex characteristics were entirely those of the female. On admission the patient weighed 220 pounds, and was five feet ten

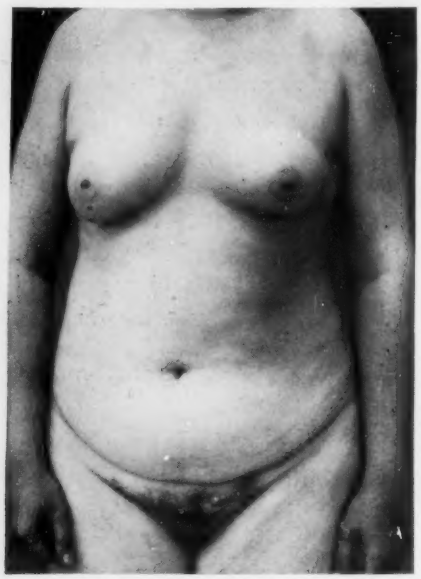

FIG. 1.—Case 1: Photograph of male, age 25, with gynecomastia, front view.

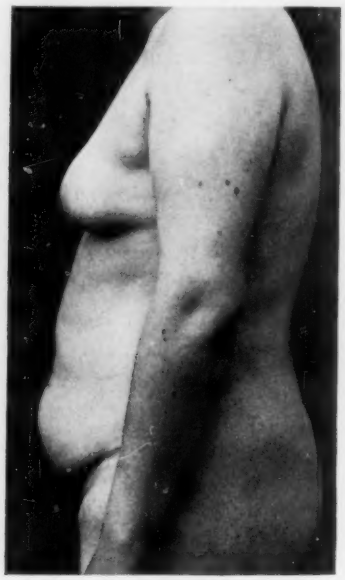

FIG. 2.—Case 1: Photograph of male, age 25, with gynecomastia, lateral view.

inches tall. Examination showed an infantile penis and no testicles in the scrotum. Basal metabolism minus 19. There was definite evidence of polyglandular deficiency. The patient sought advice because of the large size of both breasts, which caused him considerable embarrassment, particularly during the summer months in his office work (Figs. 1 and 2).

Bilateral simple mastectomy for cosmetic reasons was performed. The microscopic examination showed the structure of the breast typical of gynecomastia, similar to the microscopic picture of the normal breast tissue of an adolescent girl. In addition to the cosmetic operation, the patient was placed on thyroid and pituitary gland preparations, and after nine days of this treatment he had lost 15 pounds in weight, and basal metabolism was minus 14.

This represents a type of male breast hypertrophy in a patient with polyglandular dysfunction associated with a form of pseudohermaphroditism.

Case 2.—*Scirrhous Adenocarcinoma:* The patient, a male, age 65, gave no history of trauma. He had noted a lump in the right breast for five years. Examination showed characteristic fixation of the growth, retraction of the nipple, pigskin appearance of the skin over the tumor, and enlarged axillary lymph nodes (Figs. 3, 4, and 5). A radical breast operation was performed. Microscopic examination of the breast tumor showed a scirrhous adenocarcinoma, Grade 3. The axillary lymph nodes showed hyperplasia but no metastasis. The last report on this patient was seven years and three months after operation, at which time he was well and showed no evidence of recurrence or metastasis.

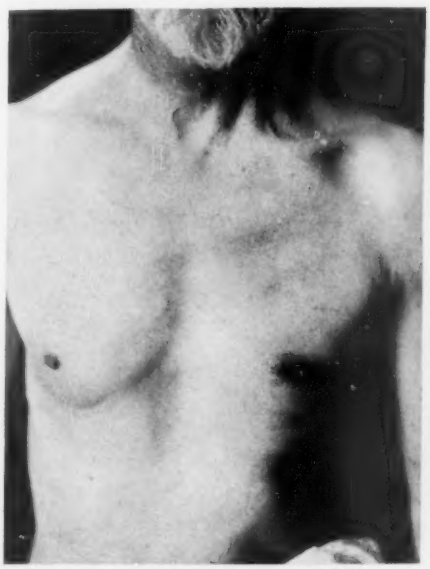

FIG. 3.—Case 2: Photograph of male, age 65, with carcinoma of right breast, front view.

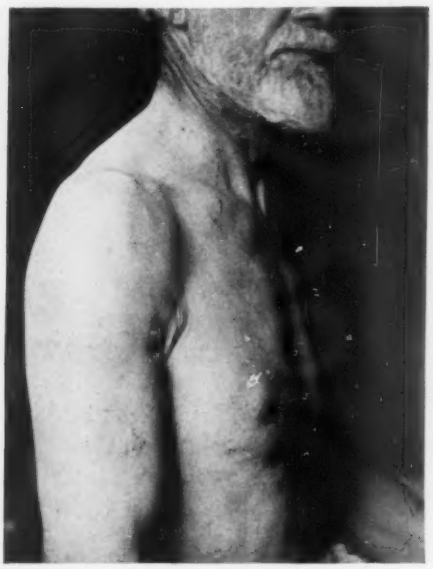

FIG. 4.—Case 2: Photograph of male, age 65, with carcinoma of right breast, lateral view.

Case 3.—*Papillary Cystadenocarcinoma:* The patient, a male, age 35, gave no history of trauma. He had noted a lump in the right breast for one year. A simple mastectomy was performed, and a cyst one and one-half inches in diameter, which contained bloody fluid, was removed. Microscopic examination showed papillary cystadenocarcinoma, Grade 2. The last report on this patient was 16 years after operation, at which time he was well and showed no evidence of recurrence or metastasis.

Case 4.—*Squamous Cell Carcinoma:* The patient, a male, age 73, had a large, foul, sloughing, ulcerated lesion of the left breast. This condition had started in what the patient thought was a mole, but the detailed history seemed to indicate an accessory nipple just above the left nipple. The lesion was of three years' duration. The first symptom was that of irritation which was produced by the wearing of suspenders and tight clothing. Biopsy showed squamous cell carcinoma, Grade 3, with a great deal of infection and sloughing.

The only operative procedure was that of biopsy of several areas, removal of sloughs and surgical dressings. There were indurated, enlarged axillary lymph nodes on the chest side. This patient was treated by irradiation, with remarkably rapid subsidence of the axillary lymph nodes and the original neoplasm. He has been followed for a little over four years, and at the present time there is no evidence of recurrence or metastasis.

Case 5.—*Metastatic Carcinoma from Testis to Breast:* The patient, a male, age 21, was admitted to the hospital in April, 1938, complaining of nausea and vomiting, loss of weight, increasing general weakness, transient swelling in the left scrotum, and multiple masses over the body. He was in good health until seven months previously, when increasing weakness developed. Two or three weeks prior to admission the patient became much worse, with frequent attacks of nausea and vomiting, rapid loss of weight, and development of multiple masses in the abdominal and neck regions. One year previously the left testicle had become swollen to the size of a small fist. There was no history of injury or of any acute inflammatory condition. The scrotal swelling persisted for several months and then subsided except for a vague indurated area in the upper portion of the left testicle. This swelling was interpreted as a mild form of epididymitis or a hydrocele, and received no treatment other than the wearing of a suspensory. Ex-

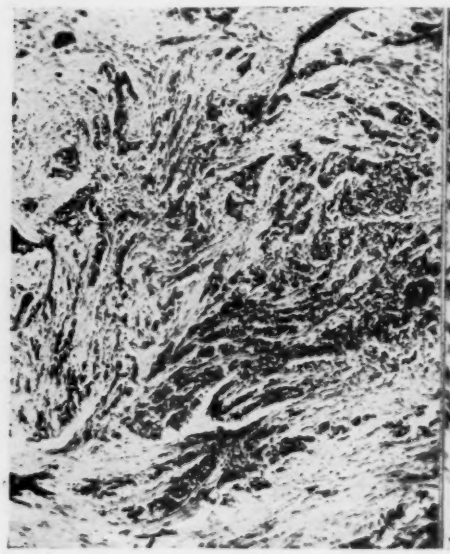

FIG. 5.—Case 2: Photomicrograph of breast, showing scirrhous adenocarcinoma, Grade 3. (×70)

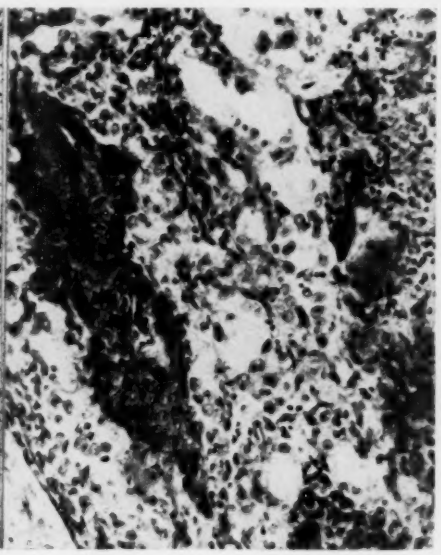

FIG. 6.—Case 5: Photomicrograph of chorionic epithelioma type of embryonal carcinoma, Grade 4, of left testis in a patient age 21. (×200)

amination showed an underweight patient, extremely dehydrated and cachectic in appearance. There was generalized adenopathy of the firm, indurated, nontender type. There was a large nodule in the left supraclavicular fossa and a smaller one on the right. Large, irregular masses could be felt in the upper right quadrant of the abdomen. These were slightly tender, moved with respiration, and extended down to the level of the navel. Rectal examination revealed many nontender, indurated, enlarged lymph nodes in the lower abdominal and pelvic regions. Examination showed atrophy of the right testicle with slight enlargement of the left testicle and some induration about the epididymis. Both testicles transilluminated normally. Roentgenograms of the chest showed multiple, more or less round, smooth, dense shadows throughout both lungs, varying from a few millimeters to several centimeters in diameter. The left breast was normal. The right breast was slightly tender, diffusely enlarged to twice the normal size, and gave the physical signs of a subacute cystic mastitis. Biopsy of the left supraclavicular mass revealed embryonal carcinoma, Grade 4, of the chorionic epithelioma type, probably primary in the testicle (Fig. 8). Aschheim-Zondek rabbit test for pregnancy was strongly positive. Blood Wassermann test was negative. Other laboratory studies were negative except for secondary anemia.

Palliative treatment with deep roentgenotherapy was administered without improvement. The patient became steadily worse, the emaciation increased, the abdominal masses enlarged with definite evidence of moderate ascites. The patient died 29 days after admission to the hospital. Necropsy showed generalized metastases, particularly in the liver, lungs and lymphatic system. Upon gross examination of the external portion of the left testicle and epididymis, no evidence of a tumor was noted, but on cut section a small infiltrating tumor in the upper portion of the left testicle was found. There was also a small hydrocele about the left testicle which contained about 6 cc. of clear fluid. Microscopic examination of the indurated portion of the left testis showed a small infiltrating primary embryonal carcinoma, Grade 4, of the chorionic epithelioma type (Fig. 6). Microscopic examination of the various metastatic lesions revealed the same pathology.

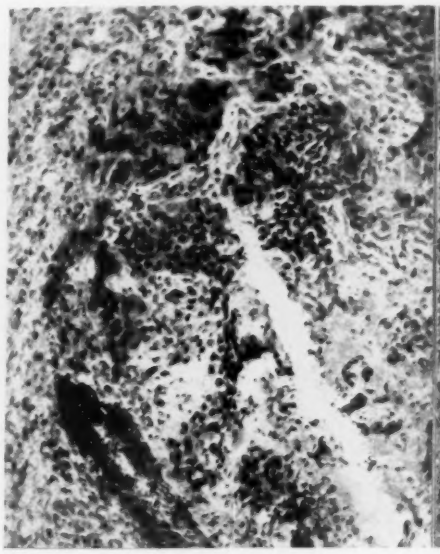

FIG. 7.—Case 5: Photomicrograph of metastasis from left testicular carcinoma to right breast, in a male patient age 21. (×150)

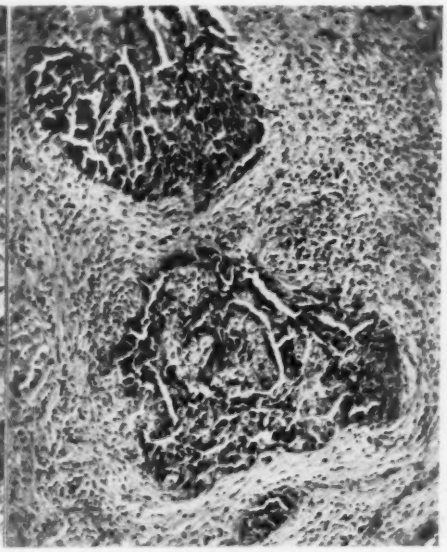

FIG. 8.—Case 5: Photomicrograph of left cervical lymph node metastasis from primary embryonal carcinoma of left testis. (×150)

Microscopic sections of the right breast showed metastasis of the primary testicle tumor into the breast tissue (Fig. 7). Also present in the right breast were areas of chronic and subacute cystic mastitis, with marked epithelial hyperplasia and one small area of what appeared to be a benign fibro-adenoma.

SUMMARY AND CONCLUSION

The ratio of breast lesions in this series is one male to 23 females. Lesions of the male breast in order of frequency are: (1) Nonneoplastic, 73 per cent (39 per cent in female); (2) benign tumors, 17 per cent (23 per cent in female); (3) malignant tumors, 10 per cent (38 per cent in female). Four cases of malignancy in the male breast are reported. The prognosis of breast tumors in the male is better than that in the female, as tumors are more easily recognized and treated in the smaller male breast.

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DISCUSSION.—DR. I. M. GAGE (New Orleans, La.): I have been interested in breast tumors occurring in the male for some time, and would like to present a most interesting and rare case occurring in a male patient about 60 years of age. The patient was admitted to the Charity Hospital, complaining of a mass in his left breast. It was impossible to obtain a history from him, due to extensive "ankylosis of his cerebral neurons." However, his wife stated that "he had had the mass in his breast for a long time."

Examination revealed a stony, hard mass about 4x4 cm. in the left breast. The mass was freely movable and was not infiltrating or attached to the overlying skin or subcutaneous tissue, was regular in outline, round and smooth. A tentative diagnosis of osteoma of the breast was made. Roentgenologic examination revealed a calcified growth in the left breast. A simple mastectomy was performed and histologic study of the specimen revealed the tumor to be a true osteoma of the breast.

As regards carcinoma of the male breast: It has been shown, statistically, that it is more common in the Negro male than in the white. I have seen six cases, one in the white and five in the colored male. The majority of tumors were located in the right breast.

The treatment should be the same as that applied to carcinoma occurring in the female, *i.e.*, radical amputation of the breast with removal of all lymphatic bearing tissues in the axilla and supraclavicular fossa.

DR. ISADORE COHN (New Orleans, La.): Doctor Horsley made one statement which should be accepted as a fact; that is, on account of the small size of the male breast we would expect a diagnosis to be made easily and early. Yet the two male breast carcinomata which I have seen came in at a late stage; one already had metastasis to the lung with fluid in one pleural cavity, and at autopsy, 18 months later, there were metastases everywhere. The second case had involvement of the pectoral muscle and axillary nodes. Why these cases came in so late, it is hard to understand. I have never seen any Negro males with carcinoma of the breast.

PLASMA CELL MASTITIS

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and

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In a paper written in collaboration with Helen Ingleby,[8] in 1930, on the subject of chronic cystic mastitis, the statement was made that that common condition was in reality nothing more than a phase of aberrant breast physiology—that it was a short step to such pathologic entities as adenofibroma, fibrocysto-adenoma and intracystic papilloma; and that it seemed likely that all three conditions were essentially the same process with variations of the theme. Now again, with her collaboration, I wish to discuss that little understood entity—plasma cell mastitis; and to state, in the beginning, that we believe, as in our paper referred to, that several other apparently unrelated pathologic processes affecting the breast are in reality modifications of the same process. We refer to plasma cell mastitis, traumatic fat necrosis, lactation mastitis and infected galactocele.

Adair,[1] in 1933, was the first to call attention to plasma cell mastitis as being a definite clinical entity. He gives Ewing the credit for being the first to name this pathologic process, based on a study of the ten cases reported in that paper. We cannot enlarge upon the clinical picture as Adair has stated it. Plasma cell mastitis is difficult to distinguish, particularly from carcinoma, and at times from such benign lesions as traumatic fat necrosis, chronic lactation mastitis, and infected galactocele. With the experience of the case to be reported, however, we would hope to at least be suspicious of this entity should we encounter it again. The greatest difficulty will be encountered in distinguishing the process from carcinoma. One must rely a good deal on a preceding history of inflammation, it is present in most of Adair's cases and in our own. Many of the usual signs of carcinoma are present—a rather hard mass, adherent overlying skin, palpable axillary nodes; but tenderness, not usually present in carcinoma, is present here. While we cannot add to the clinical description, it did seem to us, however, worth while to report the following case somewhat in detail, as it presented features, heretofore not discussed, which we hope may add to a better understanding of the pathogenesis of this rare and puzzling condition.

Case Report.—E. R. K., white, female, age 42, single, was admitted to the Woman's College Hospital, October 30, 1935, with the chief complaint of a "hardness and soreness" of the left breast for the past year. Her family history showed that her father had died of carcinoma of the prostate and her mother of pulmonary tuberculosis. There had been no serious illness other than that for which she presented herself. Her menses began at age 14. There had been no dysmenorrhea, but twice she had shown irregularity, first, about a year ago at the time of her father's serious illness when she missed two periods. She also missed the period due one month prior to admission.

There had been considerable soreness of both breasts one year prior to admission, particularly at the time referred to when she had missed the two menstrual periods. After the regular menstrual cycle was again established, the soreness of both breasts disappeared, to reappear in the left breast one month prior to admission. Some hardness had appeared around the nipple but there had been no definite tumor mass. There had been no discharge from the breast and she was not conscious of ever having had any trauma to either breast. Her last menstrual period had occurred a little over two months prior to admission, at which time the flow was slightly excessive.

Physical Examination showed nothing abnormal except in a comparison of the breasts. The left showed a somewhat hard mass in the upper outer quadrant, over which the skin seemed slightly attached and which seemed slightly tender. There was no retraction of the nipple. The entire left breast was larger than the right, the latter being normal. The heart was normal, this being important in the light of what followed. The T.P R. was normal; urine negative. *Clinical Diagnosis:* Chronic cystic mastitis of malignant potentialities.

Operation.—Under avertin-gas-ether anesthesia, the breast was turned up from the chest wall in the usual way. On incising into the breast tissue, about an ounce of creamy, purulent-like material was discharged, and thick, yellowish discharge was encountered all about the hard area. Doctor Ingleby, who was present at the operation, agreed that, grossly, the induration of the resected area, as well as of the incised breast tissue, was very suggestive of malignancy. Frozen sections showed massive infiltration with inflammatory cells, which were mingled with abnormal breast cells. The inflammation resembled that sometimes seen in the neighborhood of carcinoma, but no carcinoma could be found. Taking into consideration her age—42—a radical breast amputation was performed.

The patient left the operating table in a very poor condition. She had gone into profound shock from which she rallied slowly in 24 hours, but not without causing us considerable alarm. Her pulse remained rapid and irregular, 120 to 130, temperature 100° to 101° F. for five days postoperative. Cultures from the purulent-like material found at operation, and later of the blood stream, were negative. Her color was dusky and an Electro Cardio Gram, taken six days after operation, showed cardiac dilatation and myocardial insufficiency. She had, in spite of stimulation and digitalization, attacks of cardiac fibrillation for another week, and several times we despaired of her life. About 12 days after operation convalescence became established, but was very slow. She was not discharged from the hospital until December 11, 1935, nearly seven weeks following operation, and then still unable to stand much exertion. In about one year's time her normal health had been restored.

Pathologic Examination.—Gross: The breast was rather large and hard. On sectioning after removal, only one edge of fairly normal breast tissue was seen. The rest of the breast was partly cystic, partly gray and indurated. The cavity which was opened at operation had a fairly smooth wall and measured about 4 cm. across. A second large cavity, filled with blood-stained necrotic material, was found toward the center of the breast. Throughout the breast, inspissated purulent-like material oozed from the cut surfaces.

Microscopic Examination.—Frozen and paraffin sections were made from every part of the breast, from lymph nodes and from muscle. They were stained with H. and E., iron hematoxylin, scharlach R., sudan III, and Nile blue sulphate.

As might be anticipated from the gross appearance, cysts were a prominent feature. Many were lined only by granulation tissue and inflammatory cells. Others showed remains of epithelium but were invaded by the inflammatory granulation tissue and exudate. In yet others, the epithelial lining was intact, but they were surrounded by masses of inflammatory cells. The inflamed areas were very vascular and were packed with fibroblasts, lymphocytes, plasma cells, giant cells and occasional polymorphonuclear cells. In some places cells with eosinophilic protoplasm were abundant. Most of these

appeared to be plasma cells with an eosinophilic reaction. Others were true eosinophils. Giant cells of the foreign body type were exceedingly numerous in some areas. Occasionally they surrounded a mass of radially arranged acicular crystals. The processes of the cells then formed a radiating network around the crystals—the "giant cell rosettes" of Matthew Stewart.[9, 10] The postoperative shock and toxemia suggested that these phenomena might be due to absorption of products of protein digestion by the large operative area involved. Sheets of fat granule cells (histiocytes) were found in many places, and many of the giant cells contained globules of fat.

The lymph nodes showed an enormous hyperplasia of all elements. The surrounding fat was infiltrated with lymphocytes and new lymph follicles were being formed in it. The muscle showed fatty infiltration and hemorrhage. *Pathologic Diagnosis:* Plasma cell mastitis.

COMMENT.—As this was the first case of this condition occurring in a fairly large experience with breast lesions which we had encountered, and as it had particularly greatly puzzled me from the clinical viewpoint because of the marked shock and toxemia following operation, we became interested in trying to arrive at a better understanding of its pathogenesis. The postoperative shock and toxemia suggested that these phenomena might be due to absorption of products of protein digestion by the large operative area involved.

A search of the literature revealed, first, the important paper of Adair,[1] already referred to, which, it must be admitted, for my part, had been overlooked. Since that time, there had been a few isolated references to the condition, none of which, however, attempted in any way to explain the marked shock and toxemia following operation which were such prominent features of our own case. Gronwald, in 1931, had reported a case, prior to Adair's[1] paper, of a girl, age 16, in which "necrotic areas, granulation tissue, plasma cells, giant cells and an abundance of eosinophils were found."

We have cited the essentials of the pathologic report of our case, but since a better understanding of the pathogenesis involves primarily as complete an appreciation of the pathologic process as possible, a further discussion of this part of the case must be undertaken here.

During the study of our sections it became evident that colostrum-like cells occurred in abundance, especially in the more inflamed regions.* These were large, swollen, vacuolated cells often containing fat and resembling those cells seen in involution following lactation. Clumps of these colostrum-like cells projected into the lumen of the cysts and sometimes the cysts were filled with them. They appeared in the epithelium of some lobules, especially where the walls of ductules were breaking down to form cysts. They were found, however, in lobules which showed only slight periductal inflammation and were also seen in the connective tissue beneath the epithelium.

The fatty changes in the breast were extremely interesting. It was noted, in paraffin sections, that the fat cells in the adipose tissue appeared broken up

* Pallot[7] has described two origins for the normal colostrum corpuscles: (1) From epithelium at the beginning or end of lactation. (2) From interstitial cells (presumably histiocytes), loaded with fat, which migrate to the lumen of the ducts at the end of the premenstrual phase. Both sources were active in this case.

and were sometimes replaced by a radiating network of fine, pink-staining lines. In frozen sections, stained with Nile blue sulphate, the usual pink stain of the normal fat was changed near the inflamed areas to blue, indicating the presence of fatty acids and soaps. This was confirmed by finding acicular fatty acid crystals in many of the cells. Enormous numbers of these crystals were scattered throughout the sections. In his report of massive cholesterol deposits in the breast, Matthew Stewart[9, 10] concluded, from polarizing and chemical tests, that the crystals in his "rosettes" were cholesterol. Judging from his excellent drawings, his giant cell rosettes were morphologically the same as ours, and we expected to find cholesterol in our deposits also. Under the polarizing microscope, our crystals appeared doubly refractile, but we

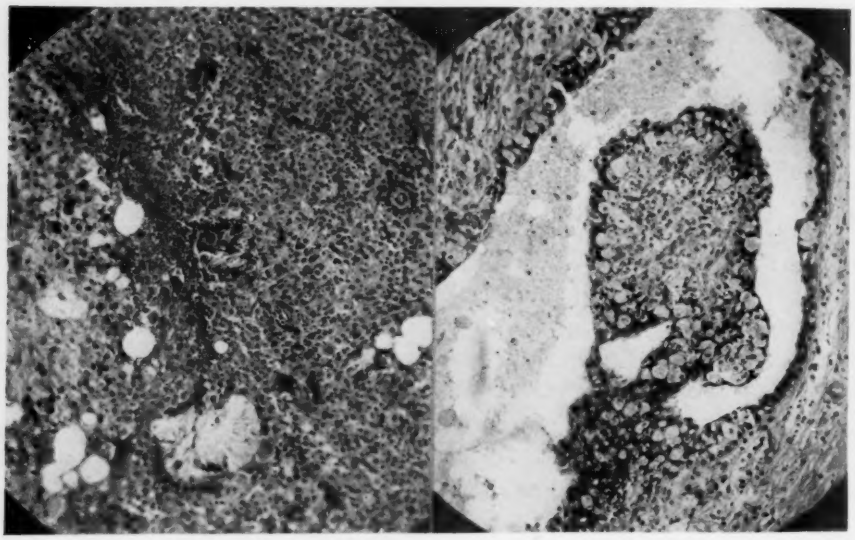

FIG. 1.—Exudate in plasma cell mastitis showing giant cell "rosette."

FIG. 2.—Colostrum corpuscles in epithelium—case of plasma cell mastitis.

believe that this was probably a pseudorefraction. Through the courtesy of Dr. Hartwig Kuhlenbeck, we were able to compare them with a known specimen of fatty acid crystals. Both behaved in the same way and their color reaction with gypsum filter was identical. A piece of breast was extracted with ether and tested chemically for cholesterol with negative results. After evaporation only one doubtful cholesterol crystal could be found.

Crystalline acid rosettes, sheafs of crystals and solitary crystals were found in the inflamed granulation tissue and in the cysts and ducts. In the granulation tissue, they were sometimes surrounded by giant cells, sometimes by a ring of histiocytes. In the cysts, a protein framework was present, but there were no surrounding cells. The smaller ducts were sometimes completely filled by radiating crystals, the duct epithelium being stretched around the rosette. Both cysts and ducts also contained large numbers of fatty particles, some free, some within shed colostrum corpuscles. The fat stains

gave the impression that, besides fatty acids and soaps, there was a small admixture of phosphatides and cholesterol fats in the ducts. If present, the amount of cholesterol was too small to confirm chemically.

The part of the breast appearing fairly normal grossly showed dilatation of the majority of the ducts. Secretion was often present in them. Occasionally cystiphorous, desquamative hyperplasia was present, and near one of the inflamed areas, a large cyst contained a multiradicular papilloma. One cyst was filled with loose connective tissue. Toward the center of one section was a large, apparently encapsulated lobule with dilated and distorted ducts. It resembled a fibro-adenoma. The epithelium in the various lobules showed different characters in different places. Colostrum corpuscles were common.

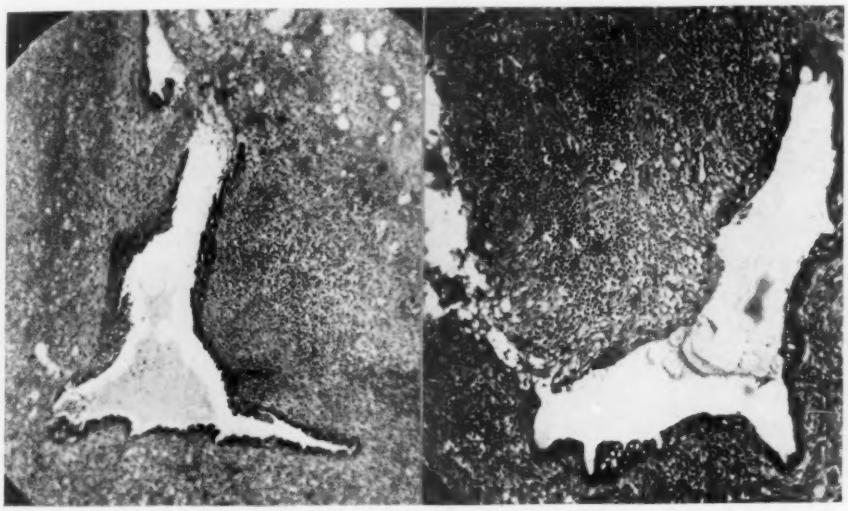

FIG. 3.—Granulation tissue and inflammatory exudate invading a duct.—Plasma cell mastitis.

FIG. 4.—Similar invasion of a duct in a case diagnosed "infected galactocele."

In the more normal lobules, the cells were fairly large and in many places definitely of the premenstrual type. There was a tendency for more than two layers of the cells to be present. In some lobules the cells were more of the interval type. Almost everywhere in the breast, the periductal tissue was abnormal. It was generally very edematous with lymphocytes and plasma cells scattered through it. Sometimes it was hyaline and then inflammatory cells were not so much in evidence.

The finding of colostrum-like cells and fatty acid crystals gave rise to the theory that the disease may be due to the action of enzymes causing splitting of milk-like substances secreted under certain conditions in breasts of non-pregnant women. It should, therefore, be closely allied to chronic lactation mastitis or infected galactocele. Cohn and Bloodgood's[2] paper aroused the suspicion that chronic lactation mastitis and plasma cell mastitis have the same underlying pathology. One of their cases occurred 14 years after lactation,

and in eight, no history of lactation is given. Unfortunately, complete microscopic description is lacking. Lee and Adair's[6] report of cases of traumatic fat necrosis gives a clue in the same direction. According to their description, the reaction to fat necrosis in the breast resembles the condition found in plasma cell mastitis, and the sections which Sir Lenthal Cheatle was good enough to give us, of one of his cases of fat necrosis, confirm this. Through the kindness of Dr. Stanley Reimann of the Lankenau Research Institute, we were able to examine four cases—one of plasma cell mastitis, two of "infected galactocele," and one of "acute and chronic inflammation." In all, the lesions were indistinguishable from those of plasma cell mastitis. The first three patients were between 40 and 50, but the last was a woman of 25 years of age, who, in addition to other typical lesions, had an abundant eosinophilic reaction. It is to be noted that all the cases had a certain number of eosinophils in the exudate and the case diagnosed "plasma cell mastitis" had a blood eosinophilia of 6 per cent. In all these cases, including our own, certain areas gave a picture resembling that seen in involution following lactation, although no history of recent lactation had been obtained in any of them. It has been shown that in women nearing the menopause there is apt to be excess of prolactin in the blood.

FIG. 5.—Breast of a rabbit showing inflammatory exudate invading a duct in experimentally provoked "plasma cell" mastitis.

Further evidence was, therefore, sought. If the splitting of milk-like substances is the cause, it should be possible to produce a reaction similar to that of plasma cell mastitis artificially.

Rabbits were used, and injections of pancreatized milk were made into the breasts of normal rabbits, a rabbit in which pseudopregnancy had been induced, and, finally, pancreatic extract was injected into a lactating rabbit.

Microscopically, the injected breasts showed one or more areas of necrosis. These were surrounded by broad sheets of deeply staining, more or less necrotic, inflammatory cells, intermingled with droplets of fat. Often a larger duct was invaded, presenting an appearance very similar to that encountered in plasma cell mastitis. Uninvaded neighboring ducts were often surrounded by inflammatory cells such as seen in the sections from clinical cases. Lobules in process of destruction appeared in some sections and their appearance closely paralleled that seen in partially destroyed areas in human sections. The rabbits showed only slight granulation tissue reaction since the lesions were recent. An interesting finding was the presence of large numbers

of eosinophile cells in the surrounding tissue. This "pseudo-eosinophilic" reaction is fairly common in the rabbit, but since it has also occurred in the clinical cases it would seem to have some significance. According to Bunting, products of destruction of lymphocytes are specifically chemotactic for eosinophils. Schecht's experiments led him to conclude that eosinophilia is an expression of a reaction of the body against toxic products resulting from the injection of foreign proteins and also from the decomposition of native proteins. The second of these factors would account for eosinophilia in the rabbit; the first and the last could quite well account for the presence of the cells in human cases.

The reaction in the rabbit's lymph nodes seemed to be of a type similar to that found in our case but at an earlier stage.

Finally, considering the clinical experience with the case reported, as already stated, we would hope to suspect this condition should it arise again. It is important to do so, since this experience has convinced us that, though closely simulating carcinoma, a radical breast amputation is definitely contraindicated because of the profound toxemia which followed. Since this condition is prone to undergo regression, we suggest waiting, possibly administering light doses of roentgenotherapy. If the lesion persists unchanged, simple amputation of the breast, followed by roentgenotherapy, would seem indicated.

SUMMARY

A case of plasma cell mastitis is reported which showed marked shock and toxemia following a radical breast amputation. A similar type of shock is seen following the absorption of products of protein disintegration. A pathologic study of our case, and the experimental evidence quoted, suggest that the shock and toxemia were due to fat splitting enzymes acting on colostrum-like substances, at times encountered in the breasts of nonpregnant women, although it must be admitted that the validity of the experiments may be called in question on the ground that any substance capable of causing tissue necrosis in the rabbit might call forth a similar response. This being true, the experiments cannot be held to prove the nature of the substance which is responsible for plasma cell mastitis in the human breast. What they do show, however, is that milk acted upon by enzymes is one way in which the lesion may be produced.

Essentially, the lesion in the human and that experimentally produced in the rabbit are the same—necrosis and invasion of the tissue including the acini and ducts, by sheets of inflammatory cells, and later, granulation tissue. In the human, colostrum corpuscles in epithelium and ducts are part of the picture. In both there is eosinophilia—more marked in the rabbit, since this animal has a tendency to this type of reaction. Eosinophilia, however, would seem to be a definite part of the reaction. Since the lesions are essentially similar in plasma cell mastitis, fat necrosis, infected galactocele, and, probably, chronic lactation mastitis, it seems likely that the same etiologic agent is responsible. This we believe to be the products of milk disintegration.

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DISCUSSION.—DR. R. L. PAYNE (Norfolk, Va.): I am particularly interested in Doctor Rodman's paper, and would like to discuss it from a little different angle than that brought out by him. My impression was that Cheatle first described plasma cell mastitis, and that later on the other contributions were made. It is possible that there is such an entity as plasma cell mastitis, but the name is misleading, and the disturbing fact is its similarity to malignancy, so that one can be deceived, both clinically and microscopically, as to the true condition.

Plasma cell mastitis was first published under this name by Cheatle and Cutler in their book on "Tumors of the Breast," and is surely a clinical, as well as a pathologic, entity of importance. Yet the name seems unsatisfactory and misleading. Of course, the predominance of plasma cells in some cases is striking, but in my opinion these are absolutely secondary. The main point of interest is the similarity of this picture to cancer. Clinical examination may give the impression of a carcinoma and, furthermore, the marked proliferation of the epithelium may even deceive an experienced pathologist. But all this is not due to the plasma cells. Nests of these cells should not be taken for cancer by the pathologist. It is the marked proliferation of the epithelium within the ducts, the formation of the epithelial giant cells, the degeneration of the epithelium, not malignant in character, but a consequence of inflammation and, furthermore, the tendency to budding of the ducts, which give the histologic similarity to malignancy under the microscope.

On the other hand, the marked proliferation of the connective tissue, especially the subepithelial connective tissue, is the reason for the cancerous appearance on clinical examination. The proliferation of the subepithelial connective tissue, the obstruction of the ducts by the latter, and the irregular proliferation of their epithelial cells, are the most striking features. Plasma cells are nothing but the expression of a chronic inflammation of long duration. They are not pathognomonic of anything.

Doctor Payne then demonstrated four slides of the same lesion, considered from both the clinical and microscopic aspects, in which all the features of plasma cell mastitis are present, except any great number of plasma cells. Although they can be demonstrated, they do not predominate at all. This case surely could not be designated as plasma cell mastitis. The infiltration is predominantly lymphocytic. As early as 1909, this picture was described by Alexander Ingier as mastitis obliterans. This name to me seems far better. Neither in this case, nor in that of Alexander Ingier, nor in those published by Hoerz and by Schultz, were plasma cells predominant. All cases showed the other features described above. So I believe the name of mastitis obliterans should be preferred.

This histologic picture was first described by Ingier (Virchows Arch.,

vol. 198, 338, 1909), in a woman, age 43, where it occurred after incision of a mammary abscess. Another case is described by Hoerz (Beitr. klin. Chir., vol. 70, 682, 1910), in a woman, age 44, who, one and one-half years after her last pregnancy, showed an acute mastitis after a blow against her breast. W. Scholz (Frankf. z. Path., vol. 43, 12, 1932) points out that the signs of mastitis obliterans are commonly found in carcinoma of the breast in 38.3 per cent of cases. He believes that the inflammatory process which leads to obliteration is a factor for local disposition and, therewith, for cancerogenesis in general. A further case is described by A. Schultz (Handbuch der Speziellen Path. Anat., VIII/2, 142, 1933).

Slide 1.—Shows a large duct nearly obliterated by granulation tissue. There is desquamation of epithelial cells in the center of the duct.

Slide 2.—Shows a corner of a larger duct. The infiltrating cells are mostly lymphocytes, but this is one of the regions where some plasma cells are found.

Slide 3.—Shows smaller ducts, likewise with proliferation of the subepithelial connective tissue and marked proliferation of the epithelium. The infiltration is merely lymphocytic. Plasma cells are absent.

Slide 4.—Shows a small duct under high power. The epithelial tissue is in marked proliferation, atypical, with giant cells, and in vacuolii degeneration. There is budding of the ducts. The infiltration is lymphocytic with some plasma cells, and shows about the maximum of plasma cells found in any of the slides.

DR. L. W. FRANK (Louisville, Ky.): I wish particularly to refer to the paper of Doctor Rodman. My discussion is not from the etiologic, or from the histologic standpoint, but from the clinical side. In connection therewith, I present two illustrations of a breast which from the external aspect (Fig. 1) shows the "pigskin" or "orange peel" appearance so typical, clinically, of carcinoma. The retraction of the nipple as seen in advanced cancer is excellently shown. The reverse side of the breast (Fig. 2) shows a large tumor mass, with an apparent cavity or cyst in the midportion. These photographs were made of a breast removed, in 1924, by radical operation, and represents one of four similar tumors which have come under observation in a series of approximately 1,000 breast tumors. The last case was operated upon ten days ago, and as yet no pathologic report has been received, though grossly, the same appearance was presented. In the specimen from which the photographs were made, the pathologist reported a fat necrosis or mastitis. We were so struck by the report and the gross appearance of the breast, that the report was put aside for future reference and study.

In 1926, we saw a similar looking breast, with enlarged lymph nodes and all the clinical earmarks of carcinoma which, upon radical removal, was also reported as a fat necrosis. A year later, a woman, age 70, presented herself with a similar appearing mass, suspected of being malignant. There was something about the tumor which made us believe it was not malignant and, with our previous experience, we felt we had a plasma cell tumor, so proceeded to remove the tumor *without* removal of the breast. It proved to be of similar character to the previously mentioned two cases. Clinically, these tumors are most difficult, if not impossible, to recognize as being nonmalignant, as the local signs are all those of cancer. However, as pointed out by Adair and Cutler, a careful history of the development of the enlargement will help materially in making the diagnosis of a plasma cell tumor, and as such we have classified the cases reported herewith. We may be mistaken—they may be fat necrosis of the breast.

The history of the plasma cell tumor is rather typical, in that, without

injury they present local redness, and some local heat and tenderness very early in their development. This soon disappears and the tenderness ceases, the "pigskin" appearance becomes evident, fixation is present and the nodes in the axilla become enlarged. It is at this stage of the disease that a diagnosis of cancer is often made. Microscopically, the cells lining the acini may also present an atypical appearance, so that we may well understand why the

FIG. 1.—Case No. 45567, Mrs. T. W. H.: Left breast showing "pigskin" appearance, with retraction of the nipple.

FIG. 2.—Case No. 45567, Mrs. T. W. H.: Reverse side of breast showing tumor mass.

report of a study of frozen sections may state that malignancy exists, and further studies, of routinely prepared sections, prove that the tumor is of the type under discussion, namely, plasma cell mastitis.

DR. J. STEWART RODMAN (Philadelphia, Pa., in closing): A great many crimes have been committed in the name of mastitis. I suggest that some rainy Thursday afternoon Doctor Payne and I get together and reclassify the whole thing. If we can prevent a reaction such as I had in doing a radical amputation for what so closely simulates carcinoma yet is definitely benign, I believe it will be worth while to have read the paper.

NONPENETRATING INTRA-ABDOMINAL INJURY

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TO PRESENT a complete discussion of all possible phases of nonpenetrating injuries of the abdomen would entail consideration of a blanket symptom-complex sufficient to cover every intra-abdominal organ. The objective of this communication, therefore, has been distinctly limited to the consideration and differentiation of shock and hemorrhage, with special reference to a somewhat neglected diagnostic aid. Case reports will be briefly summarized, but not presented in detail, and operative technic has been ignored. If this effort may serve to aid others in arriving at an early diagnosis, in order that indicated therapy or operative procedure may be judiciously applied, the purpose will have been attained.

Many of the members of this Association are, undoubtedly, required either in private or civic practice to attend acute traumatic injuries, and at the present time are connected in an active or supervisory capacity with city and county hospitals. They are aware of the gradual yet alarming transition in the nature of traumatic injuries. The type and severity of accidental injuries have been definitely influenced by the evolution incident to progressive civilization.

Half a century ago, when the Southern Surgical Association began its distinguished career, a list of acute traumatic injuries of major character would comprise: Railway, farm, home and industrial accidents, many of which threatened life only because of complications involving infection, tetanus, *etc.* During the intervening decades the automobile has grown from a one cylinder, harmless, poky vehicle, into the silent, subtle, devastating agent of to-day.

Previous to the World War the percentage of serious auto injuries in our public hospitals was within reason, considering lax traffic rules and the general undependability of the average car. Then the War; with its passing, the advent of reckless daring, bravado, and derision of all rules and regulations, particularly by the youth and the recent soldier, plus a car for every family; and there followed a sudden and alarming increase of wrecked cars and broken bodies.

Our traffic injuries in one month, at the St. Louis County Hospital, were nearly 200 in number, an average of over six a day—some of them fatal, many serious and disabling. At our City Hospital, the toll was even higher. Our roads are excellent, our streets are wide and well regulated by traffic officers and signals, and the road control system of our state is adequate; yet, our serious and fatal accidents are increasing.

Our immediate consideration is the startling mortality and morbidity which follow severe nonpenetrating abdominal injuries, generally accepted as

ranging in death rate from 40 to 60 per cent, and even higher when early hospital service is not available. The major causative factors supporting this high death rate and morbidity are hemorrhage, shock and peritonitis. In our experience, over 60 per cent of the severe type of nonpenetrating intra-abdominal injuries may truthfully be charged to automobile accidents. It is not intended to discuss the problem of prevention, although reasonable control must, in the final analysis, in accident as in disease, be predicated upon preventive measures as well as upon improved treatment.

Among the types of nonpenetrating injury are: Lacerations of all grades of the liver, spleen, kidney, mesentery, and pancreas; contusion or tear of the intestinal wall, with peritonitis; hernia of the diaphragm; ruptured gallbladder; rupture of the bladder; ileus; mesenteric thrombosis with gangrene of the intestine; strangulated ovarian cyst from traumatic torsion, and massive omental and postperitoneal hemorrhage.

In establishing a diagnosis, we are aided by the knowledge that in each grave intra-abdominal injury we may fear the advent of hemorrhage, shock, or infection from damaged hollow viscera. Serious sequelae, such as liver clot abscess, delayed or recurrent fatal hemorrhage or peritonitis from ulceration and perforation of the stomach or intestine may follow within a few hours or weeks; still later, one may anticipate adhesions, with partial or complete obstruction.

Our colleagues, Trimble, Dean Lewis, LeGrand Guerry, James Mason and Tom Orr, have all contributed valuable papers upon this subject. Wallace and Fraser and others have observed that in the very early stages of both shock and hemorrhage, the blood pressure, red cell count and hemoglobin may show little or no drop below normal. Nature first marshals her protective forces, and not until these are exhausted by repeated powerful nerve stimuli do the symptoms appear which suggest a diagnosis. This period is variable in length and may glide suddenly into one of alarming changes, indicating defeat of the physiologic defensive mechanism.

The operability of an intra-abdominal injury is usually predicated upon the surgeon's ability to gauge the physical status of the patient, and to determine whether the dominating symptoms are due to shock, hemorrhage or peritonitis. The latter is not of such urgent moment during the first few hours after injury, but it *is* important to avoid operative attack if shock is severe and there is no active hemorrhage, and equally essential to interfere if bleeding is progressive and the shock symptoms which restrain us are due to the loss of blood. Under our older system of relying upon frequent blood counts and hemoglobin estimations, we are able to distinguish with accuracy, no more sensitive variance in red cell change than a 250,000 margin; while with the more recent system now under study and practical application, frequent checking of the specific gravity of the blood, and the cell-plasma percentage, one can definitely estimate the trend of the change in the blood picture to a degree many times as sensitive as by the older method.

When confronted with unmistakable signs of combined shock and hemor-

rhage, the problem is to determine: First, whether hemorrhage is actually progressive; second, does the degree of shock forbid exploration; and third, if bleeding is uncontrolled, may one hope, by rapid antishock treatment before and during entrance, to check hemorrhage, remove the cause and maintain physiologic coherence; or will it be a safer procedure to institute stabilizing therapy, under constant observation, anticipating spontaneous arrest of hemorrhage? Herein lies the crucial test of surgical judgment.

Most of the fatal intraperitoneal cases of hemorrhage succumb within a few hours of the injury. If the bleeding is from a larger vessel in either spleen, liver, kidney or mesentery, spontaneous control is unlikely. If the lacerations of liver, spleen, or kidney are superficial in type, a slow loss of blood may be followed by massive and effective coagulation. When the tear is sufficiently deep into the liver tissue that major bile and venous radicals are severed, the presence of bile in quantity retards clotting, promotes infection and becomes a dangerous contemporary.

In injuries of the spleen, if the primary hemorrhage is not fatal, it usually ceases spontaneously, bolstered by intensive clot formation and imprisoned by the omentum and adjacent viscera. This is often followed by continued oozing within the splenic tissue until the force from within overcomes the intra-abdominal pressure, tears violently through the protective clot and adhesions, and an explosion occurs with rapidly fatal result.

Now and then portions of mesentery are torn from the small intestine and bleed profusely, accompanied by excruciating pain, nausea, vomiting and profound shock, and later by gangrene, peritonitis and death. In others, following direct trauma of a blunt object, thrombosis in the mesenteric root infrequently occurs, usually with fatal termination, the direct result of intraintestinal exsanguination.

No individual can withstand a continuous, unreplenished blood loss. Bleeding must be controlled by either physiologic adjustment or by external agents. Hasty or ill prepared exploration is often fatal, as rebleeding is established from sudden release of intra-abdominal pressure and visceral manipulation. Fatal return of visceral hemorrhage may be induced by overtreatment of shock, and may turn the tide against recovery. To overtreat shock, which is due directly to hemorrhage, is an error frequently committed. There should be an emergency service available in all hospitals, superseding all routine duties which will provide for competent, constant supervision of all cases in which shock, hemorrhage, or visceral injury is suspected. A level-headed intern, on continual duty, is an important accessory to the infrequent visit of the specialist. Hemorrhage, shock, or visceral leaks are seriously aggravated by trips to the roentgenographic room. Repeated study of the blood pressure, cell count, hemoglobin and specific gravity, frequent physical examinations, gently conducted, bedside roentgenologic examination if pneumoperitoneum or ileus is suspected, conservation of cerebral circulation by position and retention of body heat, will ultimately establish

the safest course, and prepare the injured patient for surgical intervention, if and when indicated.

Progressive hemorrhage, even if shock is profound, must be mechanically controlled; but while it is being accomplished, generous infusion of blood, glucose, and salt solution must be administered The amount of blood used in seriously exsanguinated cases is limited only by the supply of typed blood obtainable, and should approach in quantity the loss sustained. Life can be conserved if a fair blood balance is maintained.

Shock from hemorrhage can best be treated by controlling the cause, after which restabilization of the faltering physiology may be energetically applied. A most frequent error is to follow the usual routine of increasing the blood pressure with an excessive amount of intravenous fluids in a system with weakening motor power, thus withdrawing the beneficence of physiologic adjustment. It is preferable in severe cases to permit the circulation to help itself to subcutaneous fluids, while the intravenous supply may more safely follow control of active bleeding; yet in profound shock the surface capillaries are filled and stagnated and subcutaneous fluids are often taken into the general circulation too slowly for benefit when bleeding has been so severe and rapid that the vital resources are seriously threatened. An initial safe procedure is to first give a blood transfusion followed by 300 cc. of 5 per cent sodium chloride solution and 20 cc. of cortical extract, as suggested by Scudder. If, by repeating the saline and cortical extract, blood pressure is improved and capillary and venous spasm is released, exploration to control the blood loss may be possible, provided the falling-drop barometer indicates continued bleeding. We are definitely persuaded that many of our severe cases are operated upon in haste and inadvisedly, and are equally sure that others which were explored after what appeared to be wise deliberation, should have been attacked earlier. By the aid of competent laboratory service, and a careful, unbroken series of blood pressure and specific gravity readings and constant observation of the entire case-picture, with indicated medication, there is every reason to hope for, at least, a more definite assurance of prompt diagnosis and indicated treatment.

The task of identifying and distinguishing between both shock and hemorrhage and hemorrhagic shock is a tedious one. No infallible rule exists, largely because no two people respond identically to the same stimuli. A plethoric individual will develop shock less rapidly than one of high, nervous tension and an excitable disposition. Women, as a rule, withstand shock and hemorrhage far better than men. A more direct and definite power of interpretation would reduce the percentage of our erratic diagnoses, and enable us to determine progress or cessation of hemorrhage. This advance is possible if hospital and laboratory facilities are available; if constant, intelligent observation is maintained; and if the specific gravity, blood pressure, blood count and hemoglobin curves are properly interpreted and charted. Advancing leukocytosis, diminishing red cell and a falling hemoglobin index in blood taken especially from the vein, indicate hemorrhage despite the pres-

ence or absence of so-called classic symptoms, many of which appear only with approaching death. Frequent specific gravity readings assure us of a more rapid and accurate diagnostic aid in determining the operability of intra-abdominal injuries, and are one of the most helpful of our diagnostic signs in shock and hemorrhage.

In 1924, Barbour and Hamilton,[1] "recognizing the increasing importance attached to water exchange in the body for the study of many clinical and physiologic conditions," described a new and convenient method of determining specific gravity, which was demonstrated at the meeting of the Southern Medical Association, in 1928. Since that time the method has been "modified by simplification, refinement of sensitivity, and extension of scope" —until at the present time, with ease and accuracy, the specific gravity can be determined in less than one minute. A falling-drop apparatus is used, and because of the fact that the method is 25 times more sensitive than the hemoglobin test and red cell count, upon which we heretofore had to depend in determining whether concealed hemorrhage was active or dormant, we may then chart the curves frequently and accurately, and operate or withhold operation intelligently. It is of inestimable value to a laboratory service in any hospital accepting serious accidents such as those being considered herein. The article cited above presents a complete description of the method and technic of the test.

When we were required to depend upon the hemoglobin estimation as a guide to the operability of a case in which bleeding is either active or quiescent, we were handicapped by the length of time between appraisals and the insensitivity of the test, for, as stated by Scudder[4]: "The average accuracy of erythrocyte counts is a margin of 250,000," while the specific gravity test as determined by the Barbour and Hamilton apparatus is 25 times more accurate. That is, changes equivalent to 0.2 per cent of hemoglobin and to 10,000 red blood cells are shown by the Barbour and Hamilton falling-drop method. Thus, in the latter, tests may be made every few minutes in critical cases, while an interval of many times as long between tests would be necessary to determine the trend of rise or fall in red cell content or hemoglobin.

This variance in time is of momentous value when, to preserve life, we must interpret the symptoms with sufficient speed and accuracy to avoid fatal delay, or prevent premature exploration; through the specific gravity method of determining hemoconcentration, we may rapidly and accurately follow the changes.

As stated by Allen,[3] a single examination is never sufficient to differentiate shock and hemorrhage. Repeated tests are necessary, whatever method is used. He also points out the increased susceptibility to shock of a person of low hemoglobin. This application of the specific gravity test in determining the degree of shock and hemorrhage, or differentiating between them in borderline cases, has proven of great value in the emergency service of the hospitals which have adopted it. Scudder's observations are trite and helpful: "In shock uncomplicated by hemorrhage, the specific gravity of periph-

eral blood increases, indicating loss of water from the blood. In the venous blood, the anhydremia is also measured by cell volume and plasma-protein percentage by hematocrit. In hemorrhage due either to external or internal loss of blood, there occurs a fall in the specific gravity of the peripheral blood. In making blood tests in cases of shock or suspected hemorrhage, a sample of venous blood is drawn and analyzed for cell volume, plasma-protein, plasma-potassium and specific gravity. The specific gravity of the peripheral or capillary blood is measured repeatedly to note the trend and as a check upon the effect of therapy."

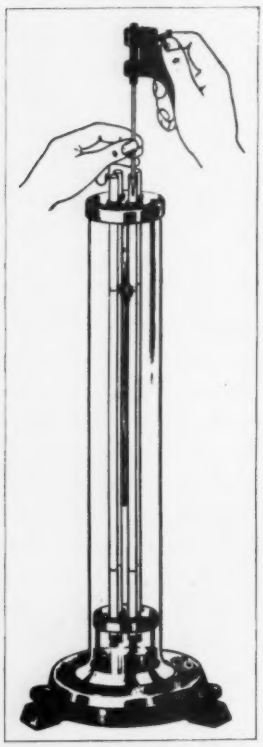

FIG. 1.—*Specific Gravity of Blood Determined by Falling-Drop Method* (Barbour and Hamilton): A 10 cm. drop of blood is timed as it falls over a distance of 30 cm. through a mixture of xylene and bromobenzene in a tube of exactly 7.50 Mm. bore. Its falling time is compared with that of a 10 cm. drop of standard K_2SO_4 solution of known density. By the use of an alignment chart, correcting for room temperature, it is possible to calculate the unknown density with accuracy, in one minute.

"Additional clinical applications of the falling-drop method of hemoglobin determinations are: Anesthesia, operative shock, acute toxemias, acidosis, severe burns and heat stroke, preeclamptic state, pyloric obstruction, dysentery, anemias, and edema, and as a guide during therapeutic correction of any of the above. It is helpful in any disease or condition wherein a knowledge of the water content of the blood is desired."

Figure 1 shows the Eimer and Amend falling-drop apparatus with Guthrie[5] pipette controller, for determining specific gravity of body fluids, plasma- and serum-proteins.* Figure 2 is a graphic illustration of the normal values in blood content, by hematocrit, specific gravity, and plasma-protein (Scudder[4]).

One hundred cases of nonpenetrating injuries from our hospital records were reviewed. Recital of the 50 cases which were selected to emphasize success and error in diagnosis and surgical judgment is omitted. The information obtained, however, may be briefly summarized:

The gross mortality in the 100 cases (all apparently severely injured) was 34 per cent. Of the 50 cases most seriously injured, in which hemorrhage or peritonitis participated, the mortality was 43 per cent. Twenty-two of the latter were explored. Eleven of these, or 50 per cent, succumbed. They comprised the cases in which exploration to control hemorrhage or infection appeared imperative. In seven of the 22 cases operated upon, the bleeding, which had been profuse, had spontaneously ceased and exploration would have been avoided had we then utilized the more sensitive test. In three of these seven, active

* The Barbour and Hamilton type of falling-drop apparatus, with Guthrie pipette control, is made by Eimer and Amend, New York, N. Y., and La Motte Chemical Company, Baltimore, Md.

bleeding was stimulated by the exploration, but was controllable by suture-pack. From the standpoint of our advanced knowledge through the newer methods of estimating concealed hemorrhage, and differentiating it from shock, we are anticipating an improvement in our death rate in these puzzling injuries, in which the worry and uncertainty of the attending physician is exceeded only by that of the injured.

Seventy-six of the 100 cases were transportation injuries (60 of them were from automobile accidents); the remaining 24 were from industrial accidents and falls in the home or from scaffold or ladder. Ten of the fatal cases followed apparently trivial injuries, so insignificant that a physician was not called or hospital service requested until several days had passed. Three of these were delayed splenic hemorrhages due, respectively, to a fall from a sled, a sharp forward jack-knife in a suddenly braked automobile, and a stumble across a ground cable.

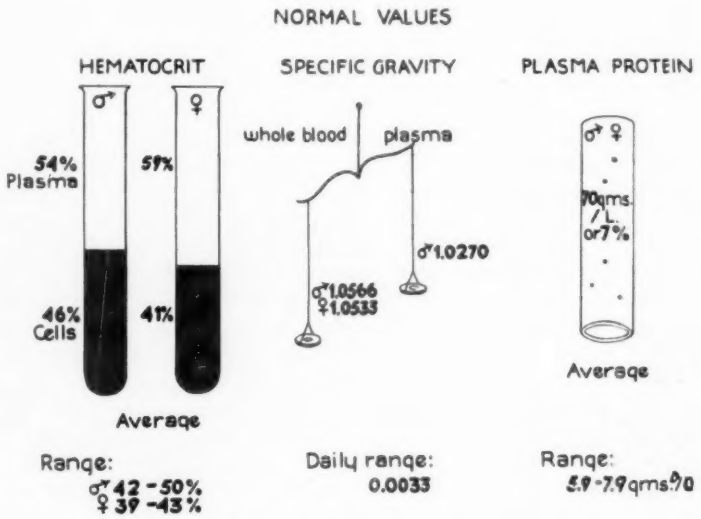

FIG. 2.—Normal blood studies (Scudder).

With the possible exception of the cases in which frank hemorrhage was clinically evident and supported by laboratory data to be present and progressive, wherein rapid exploration offers the only faint hope, it is our conviction that we have contributed to the death rate in years past by: First, inability to distinguish between deep shock and hemorrhage; second, ignoring the fact that a majority of liver and spleen injuries, which survive the primary hemorrhage, will spontaneously cease if properly treated; and third, that, while minor splenic lacerations are seldom primarily serious, the danger of rapidly fatal secondary hemorrhage, even as late as 24 days following the injury, is so great that exploration at a carefully selected time in a suspected case, with splenectomy if pathology is found, is to be advised.

We are thoroughly convinced that all general hospitals accepting accident

cases will definitely contribute to a reduced mortality if they will equip their laboratory with an efficient specific gravity apparatus, provide for a constant supervision of all acute accident cases, and provide technicians able to properly interpret the blood picture. Then surgery may be applied or withheld intelligently and confidently, in that a definite knowledge of the trend in hemorrhage or shock has replaced the uncertainty of past decades.

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DISCUSSION.—DR. FRANK K. BOLAND (Atlanta, Ga.): Doctor Bailey always gives us a timely paper. A few years ago he read a paper before the Southern Surgical Association entitled "Home Treatment of Appendicitis," in which he declared that there should be no home treatment of appendicitis. So far as I know, this was the first time the dangers of purgation in abdominal pain were particularly emphasized in a medical paper; many such papers have, however, been presented since, before both medical and lay audiences.

In his paper to-day, Doctor Bailey calls attention to the terrible and unnecessary toll of human life due to accidents. The medical profession should join the crusades against accidents now being waged by the American Red Cross, the National Safety Council, and other agencies. We should assist not only by precept but by example. Careful figures show that in the United States in one year, 112,000 lives are sacrificed to accidents, 400,000 persons are permanently injured, and 10,000,000 are temporarily injured. While it is true that more people are hurt and killed at home than anywhere else, most nonpenetrating abdominal wounds are due to automobile accidents.

Küster showed, many years ago, that if a solid organ and a viscus filled with fluid were dropped on the floor from the same distance, the one containing fluid was more apt to rupture. Thus the kidney is frequently damaged in nonpenetrating, subparietal injuries, and such damage is readily recognized by the presence of hematuria. Doctor Bailey's paper concerns especially the differential diagnosis between hemorrhage and shock in nonpenetrating abdominal injuries, and if the specific gravity apparatus he describes gives material aid in making such a differentiation, I think we can truly say, in the language of the street, "He's got something there." If one of these patients presents symptoms suggesting hemorrhage or shock, or both, he should at once be given a blood transfusion. While the transfusion is being prepared, it is our custom now to give 1,000 cc. of acacia solution intravenously. In a recent case I am sure this acacia saved a life.

I have always felt that a rapid drop in the hemoglobin reading indicated hemorrhage, while a rapid drop in blood pressure was more characteristic of shock; but of course these conditions may coexist and the signs may be interchangeable. One might consider the use of the peritoneoscope for determining the presence of free blood in the peritoneal cavity. However, while making the small opening into the peritoneal cavity for introducing the instrument might in itself reveal blood, an enormous retroperitoneal hemorrhage might be present which such an instrument would fail to show. Of

course it is much better to open one of these patients unnecessarily than to fail to operate upon one who needs it, and I do not think exploratory celiotomy kills many patients when supported by blood transfusions, acacia or Horsley's Ringer's solution with dextrose. The athletic trainer or coach who allows his players but very little to eat just before entering a contest is smarter than he knows. Many years ago, before there was any training, I recall seeing a player die from the blow of a baseball on the abdomen, which ruptured a distended loop of ileum lying just in front of the spine, causing peritonitis which was not recognized until late. The player had eaten a heavy meal not long before the game, and autopsy revealed an abdomen filled with intestinal contents. On the other hand, I saw a young football player struck in the epigastrium while attempting to catch a forward pass. Six hours later celiotomy demonstrated a transverse division of a loop of jejunum, also lying just in front of the spine. The modern coach had allowed his players only tea and toast two hours before the game, and this boy's abdominal cavity was apparently perfectly clean, and he made an uneventful recovery.

Dr. R. A. Griswold (Louisville, Ky.): Because of the increasing number of seriously injured patients seen in large city hospitals, and because we are seeing a type of trauma we formerly did not see, there has been an increased efficiency in ambulance service. We are seeing patients alive, with serious hemorrhage, who, a few years ago, would have bled to death before they reached the hospital. These patients die more quickly than the average patient we used to see with hemorrhage. The organization of hospital service to get speed of diagnosis and speed of treatment is very important. We have, at City Hospital, Louisville, tried to give these patients as speedy treatment as possible, without any of the inaccuracy that goes with haste. Most of these accidents occur at night. We keep an operating room set up with sterile instruments for complete exploratory celiotomy, in readiness 24 hours a day. A well-organized staff is essential in getting these patients to the operating room after diagnosis. The delay in getting and grouping suitable donors for blood transfusion may be fatal; acacia may satisfy the requirements, but autotransfusion is of the greatest aid. We have, with the sterile emergency set up, a flask with a two-way stopper and sodium citrate solution, which can be inserted in the regular suction apparatus. Thus we are able to start an autotransfusion on the operating room table almost immediately. We would not be able to pull some of these patients through without adequate autotransfusion given rapidly.

We have had one case with a stab wound of the intrathoracic part of the aorta and were able to start operation 15 minutes after the wound occurred. The patient had been examined fluoroscopically, and during operation he received 700 cc. of blood by transfusion. With a proper administrative set-up and the house staff on its toes, and the operating room ready to go at all times, we can save many of these rapidly bleeding patients who formerly would have been lost by delay in treatment.

Dr. Alfred Blalock (Nashville, Tenn.): Shock may be due to a decrease in blood volume, because of bleeding to the outside or into the tissues themselves, or to an increase in the size of the vascular tree, that is, the vascular system is too large for the amount of blood in circulation; or to both. It is usually stated that shock is associated with an increase in the concentration of the red blood cells, with a negative response to transfusion and with capillary congestion and hemorrhage in the tissues. On the other hand, hemorrhage is said to be accompanied by a dilution of the red blood cells, by favorable response to transfusion and by an anemic appearance of the tissues.

These statements are not necessarily true. If one withdraws blood from the experimental animal very slowly, without anesthesia, and maintains the blood pressure at a low level for a couple of hours, an increase in the concentration of the red blood cells may occur. Under these conditions, one may introduce a greater quantity of blood than has been removed and still the animal will die. The specific gravity test as outlined by Doctor Bailey may not tell us in all instances whether one is dealing with so-called shock or uncomplicated hemorrhage.

As we all know, there is a great deal of confusion concerning shock, due in part, at least, to the fact that most of us try to explain all instances of shock by one mechanism. There are many different factors which may enter into the production of shock that is associated with operations. Among these may be included hemorrhage, the anesthetic, loss of plasma from exposed surfaces, loss of fluid by sweating and vomiting, infection and the disease for which the operation is performed.

I would like to stress the fact that all declines in blood pressure are not of the same significance. If the blood volume is reduced as a result of the loss of blood, either to the outside or into the tissues, a prolonged decline in the blood pressure is of grave significance. Vasoconstriction is still present and every effort is being made to maintain an elevated blood pressure. Under these circumstances, the quantity of blood reaching all tissues is markedly reduced. On the other hand, if the decline in pressure is associated with vasodilatation, there is usually not a great diminution in the blood volume and such severe damage to the tissues does not take place. For example, following an operation on the brain, in which little blood is lost and in which vasodilatation occurs, a low blood pressure may be present for a number of hours and still the patient is likely to respond favorably to the transfusion of blood. I wish to emphasize the point that all declines in pressure are not of the same significance and that all instances of shock are not explainable by one mechanism.

Dr. J. M. Mason (Birmingham, Ala.): With the diagnostic methods that are at present employed and which are of proven value, the surgeon must still, in many instances, be guided by a "hunch" in deciding for or against operation in the presence of shock or hemorrhage. In other words, he must bring into play his most profound judgment.

The instrument which has been described may, when its findings are properly interpreted, be of material help, but it is doubtful if it will ever prove sufficiently dependable to supplant sound surgical judgment in deciding for or against operation in those confusing cases where it is difficult to determine whether shock or hemorrhage is the prevailing factor. I trust that Doctor Bailey, in closing the discussion, will tell us more about the time element in the falling blood-drop instrument.

When shock or hemorrhage is so severe that the patient does not respond to heat, morphine, transfusion or intravenous fluids, surgery has but little to offer.

Dr. R. S. Hill (Montgomery, Ala.): In connection with this paper, I wish to report four patients that were of great interest to me, in that none of them showed any marked traumatism to the abdominal wall and yet each had a serious intra-abdominal injury.

The first was a woman, age 50, who had been knocked down by an automobile. She suffered severe shock from which she only partly rallied. There was some evidence of traumatism to the abdominal wall in the right hypochondriac region. The failure to fully recover from the shock, with increas-

ing rigidity of the abdominal muscles, led to the belief that there was an intra-abdominal injury with slow bleeding. When the abdomen was opened much free blood was found coming from a torn liver. The bleeding was controlled with mattress sutures and gauze pressure. She made a satisfactory recovery.

The second patient was a lumberjack, age 30. A log had fallen across his abdomen. It required ten hours to get him from the forest, where he was working, to the hospital. We found him in extreme shock and apparently bloodless. There were an abrasion and other traumatic evidence of minor importance on the abdominal wall in the left hypochondriac region, and marked rigidity of the abdominal muscles. A diagnosis of serious internal injury with hemorrhage was made, and an immediate operation, with the administration of saline intravenously, was undertaken. Much free blood was found, and the spleen was so badly lacerated that its removal was advisable. Bleeding was controlled with forceps and gauze packing. On the second day after the operation the patient reported that something had "broken loose" in him. When the forceps were removed it was found that one was broken at the lock, leaving one-half of the distal end in the abdomen. After failure to remove this piece of the forceps with a magnet, it was left undisturbed for possibly two or three weeks, for fear that earlier effort at removal would start bleeding or otherwise prove damaging to the still seriously ill patient. He made a slow and tedious recovery.

The third and fourth patients were so similar that they may be reported together.

One was a boy kicked in the abdomen by a mule and the other a man hit in the abdomen by the end of a piece of lumber. Neither showed any marked injury to the abdominal wall, but both were in serious shock and both had extensive rigidity of the abdominal muscles. In each case there was found a hole in the small bowel about the size of a large pea. Beyond a doubt, the bowel was distended with gas and the sudden blow caused a "blow-out." Nothing worthy of note took place in their recoveries.

In conclusion, I feel the lesson to be learned from these cases is that a decision to open the abdomen in nonpenetrating wounds should rest more on the shock and rigidity of the abdomen than the extent of the injury to the abdominal wall itself.

Dr. Fred W. Bailey (St Louis, Mo., in closing): I only wish that the paper might have been omitted and only the discussion presented instead. I remember seeing the falling-drop apparatus demonstrated ten years ago, but I did not at that time recognize its potential value. There is no credit to me, whatsoever, for the development and application of this valuable diagnostic aid. It is a pleasure to have been permitted to present it to this Association, for I am sure it is a beneficial adjunct, in the effort to reach an early working diagnosis in the treatment of severe internal injury, with hemorrhage and shock as concomitant symptoms.

STUDIES ON THE REACTION OF THE PERITONEUM TO TRAUMA AND INFECTION

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POSTOPERATIVE peritonitis is still a much feared complication in abdominal surgery. Because of its varied etiology, bacteriology, and many unknown factors, once peritonitis has developed, no specific therapy other than supportive measures has proved of any definite value. At the present time our hope lies in anticipating its development and using preventive precautions against it.

It has long and commonly been believed that patients with fecal fistulae or colostomies usually tolerate secondary operations on the gastro-intestinal tract remarkably well and that even in the face of gross fecal contamination of the peritoneum, postoperative peritonitis is relatively rare. It is also frequently observed that the peritoneum can be soiled with the pus from an infected gall-bladder or pelvic abscess almost with impunity. One frequently hears the expression that the patient has an "immune peritoneum." To see whether the peritoneum of the dog could be made "immune," that is if it were protected by preliminary surgical intervention (as we are wont to believe occurs in humans) and then to discover if this protection could be quantitatively determined, the following experimental work was carried out:

The production of a uniformly fatal peritonitis, as it occurs clinically, with a minimal lethal dose of any organism or group of organisms has not been very successful. One may produce a uniformly fatal lesion by the intraperitoneal injection of organisms but fail to produce local evidence of peritonitis, or one may produce a typical fibrinopurulent peritonitis in the dog which, however, is frequently not fatal. The difficulties, therefore, of making any quantitative studies become evident. Steinberg's[1] method of using 24-hour agar cultures of *B. coli* suspended in 2 per cent solution of gum tragacanth was tried. Steinberg's "culture 300" was used and the major portion of our work is based on the use of his method.

The first problem was whether the level at which an operation upon the gastro-intestinal tract was performed made any difference in the response of the peritoneum to subsequent infection. To determine this factor, ten dogs were operated upon at various levels of the gastro-intestinal tract, similar operations being performed upon each of two dogs. The following operations were performed: Posterior gastro-enterostomy; entero-enterostomy; entero-colostomy; colocolostomy (proximal to descending colon); and lastly, the peritoneum was simply manipulated much as in an exploratory celiotomy. These ten dogs were then allowed to convalesce for two weeks, following which

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TABLE I

RESULTS OF INDUCED PERITONITIS TWO WEEKS AFTER OPERATIONS ON VARIOUS LEVELS OF THE GASTRO-INTESTINAL TRACT

No. of Dog	Procedure	Injection	Survival Time	Time of Smear	Rel. No. of Free Organisms	Rel. No. of Cells	Rel. No. of Polys	Rel. No. of Mononuclears	No. Cells Showing Phagocytosis
471	Normal—control	1 slant	6 hrs.	Postmortem	++++	+	+	+++	+++
472	Normal—control	2 slants	6 hrs.	Postmortem	++++	+	+	+++	+
458	Gastro-enterostomy	1 slant	4 hrs.	Postmortem	++++	+	+	+++	+
459	Gastro-enterostomy	2 slants	7¼ hrs.	Postmortem	++++	+	+++	+	+
460	Entero-enterostomy	1 slant	19½ hrs.	Postmortem	0	++++	+++	+	0
461	Entero-enterostomy	2 slants	6 hrs.	Postmortem	++++	+	+++	+	+
462	Ileocolostomy	1 slant	18 hrs.	Postmortem	0	+++	+++	+	+
463	Ileocolostomy	2 slants	20 hrs.	Postmortem	0	++++	+++	+	+
464	Colocolostomy	1 slant	5¼ hrs.	Postmortem	+	++++	+	+++	+
465	Colocolostomy	2 slants	6 hrs.	Postmortem	+++	+	+++	+	+
466	Exploratory	1 slant	Recovered	26 days	0	+	+	+++	0
467	Exploratory	2 slants	6¾ hrs.	Postmortem	+++	++	+++	+	+

NOTE.—Destruction of mesothelial cells was found predominantly in those animals showing a poor cellular response.

TABLE II

RESULTS OF INDUCED PERITONITIS TWO WEEKS AFTER OPERATION ON ILEUM AND COLON, WITH FECAL CONTAMINATION AT TIME OF OPERATION

No. of Dog	Procedure	Injection	Survival Time	Time of Smear	Rel. No. of Free Organisms	Rel. No. of Cells	Rel. No. of Polys	Rel. No. of Mononuclears	No. Cells Showing Phagocytosis
475	Ileocolostomy with feces on colon	1 slant	12 hrs.	Postmortem	+++	++	+++	+	+
477	Ileocolostomy with feces on colon	2 slants	6½ hrs.	Postmortem	++++	++	+++	+	+
476	Colocolostomy with feces on colon	1 slant	Recovered		No fluid obtained				
478	Colocolostomy with feces on colon	2 slants	7 hrs.	Postmortem	++++	+	+	+++	+
483	Ileocolostomy with feces on omentum	1 slant	8 hrs.	Postmortem	++++	+	+	+++	+
482	Ileocolostomy with feces on omentum	1 slant	Recovered	1 wk.	0	+++	++++	+	0
490	Normal—control	1 slant	7½ hrs.	Postmortem	++++	++	+++	+	+

peritonitis was induced by the intraperitoneal injection of living "*B. Coli* 300" (Steinberg) suspended in 40 cc. of gum tragacanth in physiologic saline solution. In order to vary the degree of the peritonitis and to grade the severity, one dog in each group was given one slant and the other dog two slants of the cultures. Two normal dogs were injected at the same time, as controls, one being given the washings of one slant and the other two slants similarly suspended. The results are shown in Table I.

It will be noted that all of the dogs in this group died except Dog No. 466. This was an enormous dog which had had a manipulation of the peritoneum and had been given one slant of the culture. Why this dog survived is not evident, since from the remainder of the work it is evident that protection and survival are not dependent upon size. Although all of the other dogs died, examination of the peritoneal smears revealed striking differences in regard to cellular response and phagocytosis. The two control dogs and the two with the gastro-enterostomies showed little evidence of effective phagocytosis; there were enormous numbers of free organisms in the smears. The others, with the exception of Dog No. 465, which had had two slants, revealed definite evidence of effective phagocytosis as shown by a marked reduction in the number of, or complete absence of, organisms. Smears from three dogs which survived 18 hours or more showed a complete absence of organisms, both free and phagocytized, and there was a relatively greater number of polymorphonuclear leukocytes as compared to the other dogs.

Since the dogs with the gastro-enterostomies showed no evidence of protection, either in survival time or cellular response and phagocytosis, and since postoperative peritonitis is more frequently a complication following surgery of the lower bowel, it was decided to limit our operative procedures to the lower gastro-intestinal tract. Furthermore, as none of the dogs in the first group showed much postoperative reaction, even though an aseptic technic was not used, it was decided to contaminate the peritoneum with feces from the dog's colon when the anastomosis was performed to give a greater reaction. In a second group, four ileocolostomies and two colocolostomies were performed on six dogs. These were contaminated at the time of the anastomosis by taking identical amounts of feces from the dog's colon on the tip of the scalpel and smearing it on the anterior surface of the midportion of the colon, or on the anterior surface of the omentum. This fecal contamination is probably about equivalent to that which occurs in the usual open anastomosis on the colon. They were then allowed to convalesce for two weeks when peritonitis was induced. One dog was given peritonitis by means of one slant of "*B. coli* 300" and the other by using two slants of the culture, both in gum tragacanth. One normal dog was given one slant of the culture as a control. The results of this group are shown in Table II.

In this group of dogs, two recovered and a third survived 12 hours. It was obvious that two slants of *B. coli* was too large a dose and it was therefore decided to limit the dose to one slant in future experiments.

In view of the survival of two of the dogs in this group it was decided to

TABLE III

RESULTS OF INDUCED PERITONITIS TWO WEEKS AFTER COLOCOLOSTOMY, SHOWING HIGHER DEGREE OF PROTECTION

No. of Dog	Procedure	Injection	Survival Time	Time of Smear	Rel. No. of Free Organisms	Rel. No. of Cells	Rel. No. of Polys	Rel. No. of Mononuclears	Number of Phagocytes
486	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	+++	++++	+	+
				1 wk.	0	+	+++	+	0
487	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	+++	++++	+	0
				1 wk.	0	+	+++	+	0
488	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	+++	++++	+	+
				1 wk.	0	++	+++	+	0
489	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	++++	+++	+	+
				1 wk.	0	++	+++	+	0
685	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	++++	+++	+	+
				1 wk.	0	+	++++	+	0
692	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	+++	+++	+	0
				1 wk.	0	+	+++	+	0
686	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	++++	+++	+	+
				1 wk.	0	+	+++	+	0
693	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	++++	++++	+	+
				1 wk.	0	+	++++	+	0
698	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	++++	++++	+	+
				1 wk.		+	+++		0
699	Colocolostomy with feces on colon	1 slant	Recovered	24 hrs.	0	+++	++++	+	+
				1 wk.	0	+	++	+	0
687	Colocolostomy with feces on colon	1 slant	16 hrs.	Postmortem	++++	+++	+++	+	0
622	Normal—control	1 slant	8 hrs.	Postmortem	++++	++	+++	+	0
623	Normal—control	1 slant	6 hrs.	Postmortem	+++++	++	+++	+	0
496	Normal—control	1 slant	7 hrs.	Postmortem	++++	++	+++	+	+

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TABLE IV

RESULTS OF INDUCED PERITONITIS ONE MONTH FOLLOWING COLOCOLOSTOMY, SHOWING LESSER DEGREE OF PROTECTION

No. of Dog	Procedure	Injection	Survival Time	Time of Smear	Rel. No. of Free Organisms	Rel. No. of Cells	Rel. No. of Mononuclears	Rel. No. of Polys	Number of Phagocytes
510	Colocolostomy with feces on colon	1 slant	5 hrs.	4 hrs.	++	+	++	+++	+
511	Colocolostomy with feces on colon	1 slant	6½ hrs.	4 hrs.	++	++	+	+++	+
514	Colocolostomy with feces on colon	1 slant	7½ hrs.	4 hrs.	++	+	++	++	+
517	Colocolostomy with feces on colon	1 slant	6 hrs.	4 hrs.	+	+++	+	+++	+
518	Colocolostomy with feces on colon	1 slant	Recovered	4 hrs.	o	++	+	++++	+
				12 hrs.	o	+++	+	++++	+
				1 day	o	+++	+	++++	o
				2 days	o	+++	+	++++	o
				3 days	o	+++	+	+++	o
				4 days	o	+++	++	+++	o
				10 days	o	++	+	+++	o
			Sacrificed	14 days	o	++	+	+++	o
524	Normal—control	1 slant	8¾ hrs.	4 hrs.	+	+	++	+++	+
525	Normal—control	1 slant	8¼ hrs.	4 hrs.	+++	+	++	+++	+

operate upon another group and to use a uniform operative procedure. A colocolostomy was performed on each of 11 animals. The anterior surface of the midportion of the colon was contaminated with feces from the descending portion of the colon, approximately identical amounts being taken on the tip of the scalpel. These dogs were then allowed to convalesce for two weeks. Peritonitis was then induced by the intraperitoneal injection of one slant of "*B. coli* 300" suspended in 40 cc. of gum tragacanth. The results are tabulated in Table III.

It will be noted that all of the dogs operated upon in this group survived except one, whereas the normal control dogs died within six to eight hours. In the surviving animals, stained smears of the peritoneal fluid, taken at 24 hours, revealed no organisms, either free or phagocytized, but there were enormous numbers of leukocytes, predominantly polymorphonuclears. After one week the relative number of leukocytes in the peritoneal exudate had decreased tremendously but the relative proportion of polymorphonuclears and macrophages did not change appreciably. In view of the low mortality in this group it would appear that a definite degree of protection was afforded by the operative procedure on the colon.

To determine the importance of time, it was decided to operate upon another group of dogs in a manner similar to those in Group 3, performing colocolostomies and contaminating the surface of the midportion of the colon with feces, but to allow them to convalesce for a period of one month rather than two weeks before the induction of a peritonitis. After one month, each dog was given the washings from one slant of the 24-hour culture of "*B. coli* 300" suspended in gum tragacanth. The results are tabulated in Table IV.

Only one of the five dogs survived, the other four dying even sooner than the controls. Apparently any protection that may have been present due to the trauma and infection from the operation had disappeared in one month.

Postoperative peritonitis in the human following surgery of the lower gastro-intestinal tract is usually due to contamination with the patient's own feces. It was therefore deemed advisable to infect a group of dogs intraperitoneally with the dogs' own feces following a preliminary operation upon the gastro-intestinal tract. Ileocolostomies were therefore performed upon three dogs which were then allowed to convalesce for a period of two weeks, as is frequently done in the human in two-stage procedures involving the lower bowel. Peritonitis was then induced, after two weeks, by the intraperitoneal injection of a suspension of 3 Gm. of the dog's own feces in 30 cc. of physiologic saline solution. This was grossly filtered in order to remove the large particles which might obstruct the needle. Three normal dogs were similarly injected with 3 Gm. of their own feces to serve as controls. Smears of the peritoneal fluid were made from four to seven hours after injection and then daily smears were made in order to study the cellular response. The results in this group of dogs are shown in Table V.

It will be seen that in this group of dogs, one of the three that had been operated upon and one of the normal controls recovered. The other two dogs

TABLE V

RESULTS OF PERITONITIS *INDUCED* BY ANIMAL FECES TWO WEEKS AFTER THE COLOSTOMY

No. of Dog	Procedure	Injection	Survival Time	Time of Smear	Rel. No. of Free Organisms	Rel. No. of Cells	Rel. No. of Polys.	Rel. No. of Macrocytes	Rel. No. of Phagocytes
576	Ileocolostomy	3 Gm. dog's own feces after 2 wks.	4 days	4 hrs.	++	++	+++	+	++
				24 hrs.	++++	+	Cells disintegrating ?		
				48 hrs.	++++	+	Many desquamated cells ?		
				4 days	+++				?
584	Ileocolostomy	3 Gm. dog's own feces after 2 wks.	Recovered	5 hrs.	+	++	++++	+	+
				24 hrs.	o	++	++++	+	o
				48 hrs.	o	++	++++	+	o
			Sacrificed	11 days	o	+	+++	++	o
586	Ileocolostomy	3 Gm. dog's own feces after 2 wks.	2 days	4.5 hrs.	+	+	+++	+	+
				24 hrs.	+	+	++++	+	+
				Postmortem	+	+	+++	++	+
612	Normal—control	3 Gm. dog's own feces	Recovered	8 hrs.	+	+	++++	+	+
				24 hrs.	o	+++	++++	+	o
				48 hrs.	o	++++	+++	+	o
			Sacrificed	72 hrs.	No fluid obtained				
				12 days	o	+	++	++	o
613	Normal—control	3 Gm. dog's own feces	18 hrs.	4 hrs.	++	+	++++	+	+++
				Postmortem	++++	Rare	—	—	o
622	Normal—control	3 Gm. dog's own feces	18 hrs.	5 hrs.	+	+	+++	+	Rare
				Postmortem	+	+	Disintegrating		

TABLE VI

RESULTS OF INDUCED PERITONITIS TWO DAYS FOLLOWING INJECTION OF *coli*-BACTRAGEN INTRAPERITONEALLY. HIGH DEGREE OF PROTECTION

No. of Dog	Procedure	Survival Time	Time of Smear	Free Organisms	Cells	Polys	Macrophages	Phagocytes
660	30 cc. *coli*-Bactragen	Recovered	24 hrs.		+	++++	+	
	48 hrs.		48 hrs.		+++	++++	+	
	2 slants "*B. coli* 300"		4 hrs.	o	+++	++++	+	o
			24 hrs.	o	++++	++++	+	o
			48 hrs.	No fluid				
			11 days	o	+	++	+++	o
661	30 cc. *coli*-Bactragen	Recovered	24 hrs.		+	++++	+	
	48 hrs.		48 hrs.		++	+++	+	
	2 slants "*B. coli* 300"		4 hrs.	+	++	++++	+	+
			24 hrs.	o	++++	++++	+	+
			48 hrs.	o	++	+++	+	o
			11 days	o	+	++++	+	o
662	30 cc. *coli*-Bactragen	Recovered	24 hrs.		++	++++	+	
	48 hrs.		48 hrs.		++	+++	+	
	2 slants "*B. coli* 300"		4 hrs.	+	+++	++++	+	+
			24 hrs.	o	+++	++++	+	o
			48 hrs.	No fluid				
			11 days	o	+	+++	+	o
665	Control—2 slants	7.5 hrs.	Postmortem	++++	+	+++	+	+
666	Control—2 slants	7 hrs.	Postmortem	+++	+	+++	+	+

operated upon survived for a longer period than the controls, one for four days and the other two days, whereas the controls died in 18 hours. Judged solely on the basis of recovery in this group of dogs, there is very little evidence that protection had been induced by the preliminary operation.

There was a distinct difference in the survival time in those dogs with fecal peritonitis compared with those in which peritonitis was induced by the gum tragacanth and *B. coli* method. Peritonitis induced by the injection of feces simulates that in the human being, and this shows that there is a period of time necessary for bacterial growth, before peritonitis becomes obvious and death supervenes. With gum tragacanth and *B. coli*, large numbers of bacteria and their toxins are introduced and, therefore, the period of growth is greatly decreased, which will account for the difference in survival time.

Finally it was decided to see if the animals could be protected against peritonitis induced by the *B. coli*-gum tragacanth method and Steinberg's *coli*-Bactragen was used. Each of three dogs was given 30 cc. of the preparation intraperitoneally. After 48 hours, each dog was given intraperitoneally the washings from two slants of the 24-hour plain agar cultures of "*B. coli* 300" suspended in 40 cc. of 2 per cent gum tragacanth. At the same time, two normal dogs were similarly given two slants of the culture. The results are given in Table VI.

The dogs protected by the preliminary injection of *coli*-Bactragen survived while the controls died. This confirms many previous similar experiments reported by Steinberg.

COMMENT.—Of the 37 dogs operated upon and in which peritonitis was induced by the *B. coli*-gum tragacanth method, there were 14 recoveries, a survival percentage of 37.8. None of the ten controls for this group survived. In the small group in which fecal peritonitis was induced, there was no evidence of protection since one of the group operated upon and one of the controls recovered.

Although there was a higher percentage of survivals in the dogs operated upon than in the normal controls, the difference was not as marked as one might be led to believe on the basis of clinical observations in the human under somewhat similar circumstances. We have not reproduced in animals, because of technical difficulties, the exact type of operative procedure such as fecal fistulae or colostomy, that are thought to give the greatest protection to the human peritoneum. However, merely observing the death or survival of the animal under these conditions does not give one an adequate idea of what actually occurs in the peritoneal cavity. Studies of the smear of the peritoneal fluid in these dogs reveal striking differences which we believe help explain in some measure the survival or death of the animal.

Cellular Response.—It will be noted in all of the groups that in the surviving dogs there was on the whole a better cellular response in the peritoneal fluid, evidenced by a rapid increase in the number of leukocytes, predominantly polymorphonuclear, and a marked decrease in the number or complete absence of free organisms within 24 hours or less. Smears of the peritoneal fluid of

these dogs were made and this study was carried out in an attempt to correlate the findings in connection with cell response and phagocytosis in the peritoneal cavity with the clinical response in the animal, *i.e.*, to see if there is any relationship between recovery or death of the dog and the findings in the peritoneal exudate. Since insufficient fluid was obtained from the majority of dogs to make accurate cell counts, the number of cells is reported as cells per oil immersion field. In Table VII is shown the cell response in the peritoneal exudate of animals recovering from induced peritonitis. As can be seen, the average number of leukocytes per field was approximately 20 in number. In Table VIII is shown the cell response in the peritoneal exudate in the normal control animals with induced peritonitis in which we find the average number of cells to be very much less, in some only a rare leukocyte being found. In the one control that did survive, there were 12 cells per field and there were no free organisms seen in the smears 24 hours after injection and in three of the survivals they had already disappeared in four to five hours. In the controls that died, however, there were enormous numbers of organisms both free and phagocytized. In both the survival and control groups there were varying numbers of cells, both mononuclears and polymorphonuclears, showing phagocytosis, some with few and others loaded with organisms. Although the individual large mononuclears or the so-called histiocytes sometimes contained large numbers of organisms, the number of these cells was usually so small that their total effect was negligible. The polymorphonuclears with fewer organisms per cell were present in such great numbers as to make it seem fair to assume that these cells play a dominant part in the recovery of the animals. These observations are not in apparent agreement with some of the other workers,[2] but an explanation of these discrepancies is offered by Steinberg and his colleagues[3] on the basis of the difference in the animal employed and through different interpretation.

In Table IX are listed all of the animals showing free organisms in the peritoneal smears within 24 hours after the induction of peritonitis, all smears being taken postmortem.

From the foregoing tables it may be noted that none of the dogs survived in which the organisms did not disappear within 24 hours after injection. In some of the dogs the organisms disappeared in a shorter time, but they did not survive. In these dogs it must be assumed that death was due to toxemia resulting from the overwhelming toxin injected with the organisms and that death was not due to toxins liberated as a result of bacterial proliferation. However, since only those dogs in which there was a rapid disappearance of organisms survived, and since this occurred only in those with a relatively good cell response in the peritoneal cavity, it may be assumed that phagocytosis is an important factor in the survival of these animals. Furthermore, on the basis of percentages of cell types found in the peritoneal exudate, it may also be assumed that the polymorphonuclear leukocytes are of prime importance in spite of the fact that the few mononuclears present showed a greater capacity for phagocytosis as evidenced by the relatively greater number of engulfed

TABLE VII

MICROSCOPIC FINDINGS IN THE PERITONEAL EXUDATE OF ANIMALS WHICH SURVIVED INDUCED PERITONITIS

No. of Dog	Procedure	Av. No. Cells per Field	Rel. No. of Free Organisms	Per Cent of Polys	Per Cent of Mononuclears	Survival Time	Time of Smear
482	Ileocolostomy, 1 slant "*B. coli* 300"	18	0	98	2	Recovered	1 wk.
486	Colocolostomy, 1 slant "*B. coli* 300"	25	0	95	5	Recovered	24 hrs.
487	Colocolostomy, 1 slant "*B. coli* 300"	26	0	92	8	Recovered	24 hrs.
488	Colocolostomy, 1 slant "*B. coli* 300"	16	0	91	9	Recovered	24 hrs.
489	Colocolostomy, 1 slant "*B. cole* 300"	35	0	87	13	Recovered	24 hrs.
518	Colocolostomy, 1 slant "*B. coli* 300"	18	0	95	5	Recovered	4 hrs.
532	Colocolostomy, 1 slant "*B. coli* 300"	17	0	96	4	Recovered	4 hrs.
584	Ileocolostomy, 3 Gm. feces	6	0	96	4	Recovered	5 hrs.
685	Colocolostomy, 1 slant "*B. coli* 300"	20	0	97	3	Recovered	24 hrs.
692	Colocolostomy, 1 slant "*B. coli* 300"	15	0	96.2	3.8	Recovered	1 wk.
686	Colocolostomy, 1 slant "*B. coli* 300"	14	0	95	5	Recovered	1 wk.
693	Colocolostomy, 1 slant "*B. coli* 300"	29	0	98	2	Recovered	24 hrs.
698	Colocolostomy, 1 slant "*B. coli* 300"	16	0	93	7	Recovered	24 hrs.
699	Colocolostomy, 1 slant "*B. coli* 300"	24	0	94.5	5.5	Recovered	24 hrs.

TABLE VIII

MICROSCOPIC FINDINGS IN PERITONEAL EXUDATE IN CONTROL ANIMALS UNPROTECTED AGAINST INDUCED PERITONITIS

No. of Dog	Procedure	Av. No. Cells per Field	Rel. No. of Free Organisms	Per Cent of Polys	Per Cent of Mononuclears	Survival Time	Time of Smear
471	Normal—control, 1 slant "*B. coli* 300"	1	++++	8	92	6 hrs.	Postmortem
472	Normal—control, 1 slant "*B. coli* 300"	Occasional	++++	9	91	6 hrs.	Postmortem
490	Normal—control, 1 slant "*B. coli* 300"	5	++++	75	25	7.5 hrs.	Postmortem
496	Normal—control, 1 slant "*B. coli* 300"	7	++++	88	12	7 hrs.	Postmortem
524	Normal—control, 1 slant "*B. coli* 300"	Occasional	+++	65	35	8¾ hrs.	Postmortem
525	Normal—control, 1 slant "*B. coli* 300"	2	+	60	40	8½ hrs.	Postmortem
543	Normal—control, 1 slant "*B. coli* 300"	8	+	58	42	10 hrs.	Postmortem
544	Normal—control, 1 slant "*B. coli* 300"	Occasional	+++	Poorly	Stained	6¾ hrs.	Postmortem
612	Normal—control, 3 Gm. feces	12	0	98	2	Recovered	24 hrs.
613	Normal—control, 3 Gm. feces	Rare	++++	0	100	18 hrs.	Postmortem
622	Normal—control, 3 Gm. feces	Occasional	++	90	10	18 hrs.	Postmortem
624	Normal—control, 1 slant "*B. coli* 300"	5	++++	80	20	8 hrs.	Postmortem
623	Normal—control, 1 slant "*B. coli* 300"	8	+++++	76	24	6 hrs.	Postmortem

organisms. The percentage of polymorphonuclears in the survivals is definitely higher than in those that died. The average was 70.3 per cent in the group that died and 93.7 per cent in the group that survived. Although the numbers of leukocytes in the smears of the survivals rapidly decreased after the first few days, the percentage of polymorphonuclears did not decrease so rapidly. During the first 24 hours, the smears showed an average of 93.7 per cent polymorphonuclears and after one week the average was still 73.4 per cent.

TABLE IX

MICROSCOPIC FINDINGS IN PERITONEAL EXUDATE IN ANIMALS SHOWING FREE ORGANISMS. THERE WERE NO SURVIVALS

No. of Dog	Relative No. of Free Organisms	Number of Cells per Field	Survival Time	Time of Smear
458	++++	Occasional	6 hrs.	Postmortem
459	++++	1	7½ hrs.	Postmortem
461	++++	Occasional	6 hrs.	Postmortem
464	Occasional	25	5¼ hrs.	Postmortem
465	+++	Occasional	6 hrs.	Postmortem
467	+++	9	6¾ hrs.	Postmortem
471	++++	2	6 hrs.	Postmortem
472	++++	Occasional	6 hrs.	Postmortem
475	+++	4	12 hrs.	Postmortem
477	++++	7	6½ hrs.	Postmortem
478	++++	Occasional	7 hrs.	Postmortem
483	++++	Occasional	8 hrs.	Postmortem
490	++++	6	7½ hrs.	Postmortem
496	++++	7	7 hrs.	Postmortem
510	++	3	5 hrs.	Postmortem
511	++	5	6½ hrs.	Postmortem
514	++	3	7½ hrs.	Postmortem
517	Occasional	35	6 hrs.	Postmortem
524	+++	Occasional	8¾ hrs.	Postmortem
525	+	3	8¼ hrs.	Postmortem

Smears made from a peritoneal exudate are valuable in determining the prognosis of the disease. If the smear shows large numbers of bacteria with few leukocytes, the prognosis is grave. If, however, there are seen few or no free bacteria and large numbers of leukocytes, the prognosis will be good. Intermediate stages may be seen in which the prognosis must be indeterminate. Garnier,[4] in 1897, drew attention to this fact as a result of his experimental work on animals, and Wilkie,[5] in 1913, reported the clinical application of this method to a series of patients with peritonitis in which he found the observation to have definite value in prognosis. We have used the method for years and have found it fairly accurate and of definite value to the surgeon In these experiments, we find that survival is associated with a rapid disappearance of bacteria from the peritoneal exudate and that the rapid disappearance of the organisms is associated with an adequate cell response. There is a preponderance of polymorphonuclear leukocytes in the dogs, particularly in those animals

which survived. This preponderance persists in most of the survivals for a week or more.

CONCLUSIONS

(1) Under the conditions of these experiments, and judged on the basis of complete recovery or survival time, there is an enhanced resistance to infection resulting from the surgical manipulations in the peritoneal cavity. This is insufficient to protect the animal against a severe form of peritonitis, but it may be protected by other means.

(2) On the basis of our observations, it is our opinion that survival is related to the character and degree of the cellular response in the peritoneum.

(3) Phagocytosis in the peritoneal cavity is an important factor in survival of the dogs with diffuse acute peritonitis.

(4) The polymorphonuclear leukocyte is the important cell in the phagocytosis and consequent recovery.

(5) Examination of the smear from peritoneal exudate may be of value in determining the prognosis of acute peritonitis.

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APPENDICOCECOSTOMY IN THE TREATMENT OF PERITONITIS

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During the past 30 years there has appeared, at varying intervals, an occasional article calling attention to the use of cecostomy, or appendicocecostomy, in the treatment of peritonitis. The results in all these reports that I have been able to examine have been most favorable. We first made use of this procedure in 1931. Groves, in 1909, described the value of this operation in fulminating appendicitis with peritonitis. Jackson, in 1917, reported 18 cases of acute fulminating appendicitis, with perforation and peritonitis, that he thought were benefited by appendicocecostomy. Brussock and Combs, in 1925, reported a series of similar cases advocating its use. Maes, in 1925, in reporting a series of ruptured appendices, called our attention to the fact that those who developed fecal fistulae following appendicectomy usually recovered.

Since the various causes of peritonitis are familiar to you all, I shall not discuss them here, but will limit what I have to say primarily to peritonitis following ruptured appendicitis, which is by far the most common cause.

It is generally considered that surgery offers the best treatment for peritonitis, whatever may be the cause. When surgery is to be instituted in the treatment of any disease, we must keep in mind that in order to get the best results, we must remove or correct the pathology present in that particular disease.

Let us look into the pathology and see what happens when the appendix ruptures. A seropurulent exudate always appears, varying in character and quantity with the extent of the disease. The exudate usually has a foul odor, and may contain gas, which may be coming from either the bowel itself, or from the decomposing action of the bacteria present. Beyond the limits of gross infection, there may be, and usually is, a large amount of turbid fluid which is often erroneously interpreted as a general peritonitis. In the early stages, however, this exudate is usually sterile, and it has been a source of many errors in compiling statistics on diffuse or general peritonitis. The peritoneum soon loses its luster and becomes dull and generally reddened. The walls of the intestines are edematous, thickened, and over the surface may be seen fine ecchymotic hemorrhages; the fibrin may also be so firmly fixed to the surfaces as to resist the wiping off with gauze. The loops of bowel, as well as viscera, become matted together, depending upon the amount of fibrin in the exudate.

In the early stages, we have cessation of peristalsis, which serves a good purpose, in that it helps prevent the spread of infection, retards absorption, and aids in localizing the infection by a walling-off process. Later, the bowels become more or less paralyzed, and finally, as the atony becomes more complete, marked distention occurs, which is increased by the decomposing bowel

contents. On account of the difference in character of the bowel contents, the gas formation and distention naturally begins in the colon and progresses upward along the small bowel. Then we have developed a more or less complete paralytic intestinal obstruction, which I am sure is the cause of death in many cases of peritonitis.

With the foregoing pathology in mind, let us see what surgery offers. Make a McBurney or right rectus incision. You will usually find that the cecum in all of these cases is greatly distended. Locate and free up the appendix; place a purse-string about its base; amputate it close to the cecum, and introduce a small rubber catheter through the stump into the cecum, a distance of three or four inches. The edge of the stump is inverted and the purse-string tightened and tied. The catheter is then brought out through a small opening in the great omentum, if possible. One cigarette drain is usually placed about the head of the cecum, and one rubber tube placed into the pelvis for drainage. The catheter may either be brought out of the abdomen through the incision or through a stab wound to the right—whichever is most convenient. After the patient is returned to bed the catheter is connected up to a bottle by means of a rubber tube.

With this operation you relieve at once the marked distention of the colon and establish a better circulation in the bowel; the mucous membrane assumes a more normal condition, and is more capable of absorbing saline solution. As you well know, the ascending colon has a greater absorptive power than any other portion of the bowel. Now, we can take full advantage of this fact by introducing large quantities of saline solution into the bowel, where it is readily absorbed, diluting toxins and restoring the depleted chlorides, as well as passing through the lymphatics into the peritoneal cavity and causing a more profuse abdominal drainage. This is about the best method I know to wash out the abdominal cavity. The catheter in the cecum will not only allow the escape of gas, but there will be considerable drainage of fecal and toxic material, thus materially relieving the obstruction—and with this, the cardiac action and general circulation is greatly improved. Many of you can no doubt recall a case in your own practice which, following operation, became greatly distended; heart action bad; and suddenly developed a fecal fistula—and soon got well.

During the past six or seven years, Dr. L. W. Boggs and I have performed a cecostomy or appendicocecostomy on 52 of what we considered to be our worst cases of ruptured appendicitis, most of them having a general peritonitis. We have not employed this operation in recently ruptured cases, although I am sure there is no contraindication for doing it on such cases, and I think many of them would have a smoother convalescence with it—nor have we used it in any with a walled-off abscess.

Of the above number of cases, we have had six deaths, a mortality of approximately 12 per cent. This compares favorably with other statistics. Finney, Jr., reports 240 cases of ruptured appendix—50 died, or 22.8 per cent. Sworn and Fitzgibbon report, from St. Thomas Hospital, London, 231 cases of ruptured appendicitis with peritonitis, 19 per cent.

All the cecostomies closed in from two to three weeks without anything being done, except in one case, which was reoperated upon after two months, when the fistula was closed.

I believe all hospital records will show that very few cases of perforative peritonitis escape the complication of paralytic ileus with all its distressing symptoms. It has been my observation that they are all desperate cases. The operation of primary appendicocecostomy is not new, but, for one reason or another, has not been employed generally. As far as I have been able to determine, it has no undesirable effects, and certainly it has many advantages. Therefore, I recommend its employment, for I believe the patients upon whom it is undertaken will have a much smoother convalescence—and frequently it will save a life.

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Discussion.—Dr. Charles Gordon Heyd (New York, N. Y.): In 1935, 16,142 people died as the result of acute appendicitis. About 90 per cent of these died of peritonitis and, therefore, the average surgeon must meet all the complications of this disease. The speaker has indicated the use of appendicocecostomy in the treatment of peritonitis. This operation is one of the technical procedures in the treatment of acute appendicitis. In a consideration of the entire subject of peritonitis, one must realize that, strictly speaking, there is seldom a completely generalized peritonitis, in that the entire peritoneal cavity is not uniformly affected. Every case of peritonitis will begin or end with a pelvic peritonitis, and the mechanical factor of intestinal obstruction is the predominant feature of peritonitis. If you recall, there is a gastro-intestinal-hepatic circulation of fluid which varies from seven to ten quarts per day, and this fluid may be lost in part, or in whole, when there is a diffuse peritonitis. The mechanical obstruction of the small intestine and sigmoid is part and parcel of the disease. One has only to recall the effortless regurgitation and vomiting of huge quantities of fluid from the stomach to realize that there is no onward movement of the intestinal contents. Peristalsis is not inhibited, as is evidenced by the reflux of such immense quantities of material into the stomach.

The loss of the chemical elements by vomiting or gastric lavage induces sudden changes in blood chemistry, with the development of hypochloremia and alkalosis.

Ileostomy has been employed on many occasions. If one reads the bedside notes following an ileostomy, he is impressed with two significant factors: (1) There is the record of the ileostomy tube draining 100 to 150 cc. of material; and (2) the ileostomy tube ceases to drain. In other words, only a distended loop of intestine is drained by an ileostomy. The intestinal obstruction in peritonitis following acute appendicitis embraces two phases: (1) That involving the terminal ileum. The last third of the small intestine is under normal conditions lying in the pelvis. With the infection of contiguous loops of the terminal ileum, there are inflammation of the wall of the intestine, angulation and obstruction. (2) If the infective process continues, the varying redundant loop of the sigmoid is involved and the same mechanism

of obstruction is here produced. This double type of intestinal obstruction was designated by Handley, "ileus duplex." For this condition Sampson Handley, of London, devised an operative procedure which in our hands has been eminently successful. In brief, Doctor Handley proposed an ileocolostomy plus a tube colostomy, proximal to the anastomosis. An incision is made, under local anesthesia, in the upper left rectus, the omentum divided, and the first presenting distended loop of jejunum is united to the undersurface of the transverse colon by a lateral anastomosis. After the closing of this wound an incision is made, under local anesthesia, along the right costal margin and a Pezzer, self-retaining catheter is inserted to make a tube colostomy in or about the region of the hepatic flexure. The after-result of these two technical procedures is an almost immediate cessation of regurgitation of material into the stomach, and the essential intestinal fluid with its peculiar and necessary chemical elements is preserved in the large and ample colon.

At the end of 24 hours, the tube colostomy begins to drain, but rarely is more than 500 to 700 cc. of material lost per diem. At the end of 72 hours, fluids and carbohydrate material may be given by mouth.

We have performed this operation six times in desperate and hopeless cases, and succeeded in saving five of the six individuals.

Dr. William H. Prioleau (Charleston, S. C.): I would like to report my experience with this procedure. In about 150 operations for acute appendicitis, appendicocecostomy was performed in 27 cases, the youngest, aged two and the oldest 60. In every case the cecostomy tube was brought out through a McBurney incision, though in several cases in which the diagnosis was doubtful a straight incision was made first. In each case rubber tissue drains were placed along the parietal peritoneum, to the pelvis and along the right lumbar gutter, and brought out along the cecostomy tube. No attempt was made to bring the cecum up to the anterior abdominal wall.

Cecostomy was performed in advanced cases of rupture of the appendix with well-developed peritonitis of varying extent, and in a few cases of localized abscess formation. In some cases there was profuse discharge of intestinal contents through the tube, in most cases only moderate, and in a few practically none; therefore showing that cecostomy had a variable influence upon the prevention of distention of the intestines. The tube was passed into the cecum or withdrawn on about the tenth day. In one case, there was drainage of fecal contents for 14 days after operation and in another for 30, but in no case was there a fistula which required operative closure. In some cases there was pelvic induration and in a few evidence of subdiaphragmatic inflammation, but in no case was a secondary operation necessary for drainage of an abscess. In all cases operation was performed as soon as the general condition of the patient made it advisable, usually within a few hours after admission. In one case, there resulted weakness at the site of the incision, but in no case has a hernia developed. Fluid was not administered through the cecostomy tube, on the assumption that it would not be conducive to the maximum rest.

In this series of 27 cases, there were two deaths, a mortality of 7.4 per cent. In one case, a Negro, age 32, the onset of the illness was nine days before admission. Persistent vomiting, lack of bowel movements, and the presence of chills and fever were the outstanding symptoms. There was induration in the pelvis, and the ileocecal region was involved in an inflammatory mass. Death occurred on the eighth day after operation. A limited postmortem examination showed no accumulation of pus, but an involvement of the small intestine in an inflammatory mass likely causing obstruction.

In another case, a Negro, age 26, the disease had existed seven days before admission. Persistent vomiting and absence of bowel movements were the outstanding symptoms. With a diagnosis of peritonitis of undetermined origin and with an inflammatory mass in the left lower quadrant, a low left paramedian incision was made. An extensive peritonitis originating from the appendix was found. The patient developed bronchopneumonia and died five days after operation.

Dr. J. G. Sherrill (Louisville, Ky.): When you take up the question of appendicitis and acute peritonitis, you are going through what we went through 30 years ago. The question of whether the patient lives or dies with acute appendicitis depends upon the first doctor who sees him. If the first man gives a large purgative, the case is lost. Appendicectomy and cecostomy are both of advantage in the proper time and place, but with the large series of cases of peritonitis, there is something wrong at the time these cases reach the surgeon. They should come to the surgeon quickly, and with no purge. Wash out the stomach and keep washing it out and give fluids by proctoclysis, and operate promptly. Blake washed out the abdomen. This is not done now. Finney had the courage to get up and apologize to this Association for wiping off the intestine. Murphy said, "quick in, quick out and drain" and had the best results. Pool's pump removes more material from the inside of the abdomen than anything else. You can take it out with the pump during the operation.

Dr. John C. A. Gerster (New York, N. Y.): In regard to Doctor Heyd's suggestion, namely, to anastomose small intestine to transverse colon, one must be certain the loop of small intestine selected does not lie too high. The speaker heard of a case of a high jejunal anastomosis to the transverse colon followed by intractable diarrhea, rapid inanition and death.

Dr. Frederic Bancroft (New York, N. Y.): I should like to offer a modification in cases where the ileum is dilated. One can introduce a catheter through the appendiceal stump and then, with the hand on the outside of the cecum, guide the tip of the catheter through the ileocecal valve into the terminal ileum. When the tip has been passed far enough to allow ileal drainage, a lateral fenestration may be made in the catheter and this fenestration pushed downward until it enters the cecum. In this manner both the ileum and the cecum can be decompressed.

Dr. Reginald Jackson (Madison, Wis.): I would like to endorse everything Doctor Reeves has said. He referred to a report we made in 1917; I still believe that appendicocecostomy in selected cases is a life-saving measure. I think the high mortality of acute appendicitis with spreading peritonitis—of this generation of surgeons—is partly due to the fact that many of them do not go back to the methods of the old masters, like McBurney, who seemed to be able to locate, intuitively, the exact place of the inflamed appendix, and then make an incision only large enough to permit "sneaking out the appendix" without plunging through the protective barrier zone, as is so often done to-day by those who use large incisions and multiple pads.

Dr. T. B. Reeves (Greenville, S. C., in closing): You will notice that I have not taken up what I consider the proper method of treatment of appendicitis, but have discussed only treatment for the most serious cases—those that have a general peritonitis when first seen. In addition to putting a tube in the cecum, we also use the Levine tube in many cases, which I am sure does good. I think drainage of the bowel is worth while in cases of peritonitis and will save most of those patients who would ordinarily die from intestinal obstruction.

UNUSUAL SPLEEN CASES

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THE cases here presented have been selected not with any idea of covering the field of splenic disease, but simply as individual cases showing unusual findings.

The first paper in the first volume of the Archives of Surgery, which appeared in July, 1920, is entitled Two Cases of Splenectomy for Splenic Anemia, by Dr. Harvey Cushing, and is accompanied by A Report in the Pathologic Changes in Splenic Anemia, by Dr. W. G. MacCallum. Doctor Cushing's description of his first case begins as follows:

CASE REPORTS

Case 1.—"There came to the Johns Hopkins Hospital, March 9, 1898, a man, age 33, C. D. B. by name, a farmer from Fincastle, Virginia, complaining of dyspepsia and hemorrhage from the stomach and bowels. These he had had for nine years, the loss of blood at times having been sudden and very profuse, the attacks coming possibly once every 12 months. I remember him as a little fellow with a curious brownish coloration of the skin and a big spleen which was taken to be an ague-cake, doubtless in view of his place of domicile. He had a marked anemia with hemoglobin of 25 per cent, about 3,000,000 reds and a leukopenia of 2,800 cells."

Doctor Cushing was at the time Resident Surgeon, and after consultation with Doctor Osler, he removed the spleen. This is listed as the twelfth case of cure of Banti's disease by splenectomy, the first dating back to Spencer Wells, in 1862.

In his pathologic report, Doctor MacCallum described "a definite new growth of connective tissue between the venules" but "no progressive sclerotic process, such as is described by Banti, is seen in the malpighian bodies," and, therefore, contents himself with a diagnosis of splenic anemia.

Mr. C. D. B. had an uninterrupted postoperative recovery, and after his return home kept in touch with Doctor Cushing until 1909, reporting occasional vomiting of blood.

On reading this report, in 1920, we looked up this patient, found him still living and running his farm, and so reported to Doctor Cushing. In October, 1938, we again got in touch with Mr. C. D. B., found him confined to bed with a cardiorenal insufficiency. This patient is now age 73, and it is 40 years since the removal of his spleen. Blood examination at this time, October, 1938, shows a simple secondary anemia. Hemoglobin 57 per cent; R.B.C. 2,800,000; W.B.C. 4,200, platelets 206,000.

Case 2.—Mrs. R. L. K., age 34, June 10, 1930. This patient first noticed a left upper abdominal mass, 22 months before coming to the hospital, four months before the delivery of her third child. The mass was not tender, and was discovered only because it interfered with her stooping over to put on her shoes. Since discovering the mass, she has lost 50 pounds in weight (185 to 135), and has been troubled with diarrhea, which has not been bloody.

Examination of the abdomen shows an oval, rounded mass extending from beneath the left rib border to the midline, where a notch can be felt. R.B.C. 4,570,000; W.B.C. 4,650, Wassermann and Kahn tests negative.

At operation, the spleen was found to be enlarged to about the size of a man's head, but somewhat oval in shape. On examining the tumor after removal, the cut surface was soft and presented a yellowish-white appearance, suggesting a very cellular growth. Microscopic sections showed the typical picture of a Gaucher's splenomegaly.

It will be noted that the blood picture was only slightly affected by the presence of this type of splenomegaly, and that splenectomy produced only a slight increase in the total number of leukocytes. This shows a striking contrast with the effect of splenectomy in Case 6.

There was an uneventful recovery, and a check-up two months later showed a marked improvement in her general condition, the blood picture being R.B.C. 4,940,000; W.B.C. 6,850, normal differential.

Case 3.—Hospital No. 37762: Thelma G., age 8, June 21, 1935. Only five weeks prior to admission, the patient developed swollen nodes in the left cervical region, accompanied by headache, severe sore throat, cramp-like abdominal pain and fever of 104° F. There was no nausea or vomiting, no diarrhea, and no G. U. symptoms. Past history negative.

Examination on admission shows a well developed girl, pale, listless and evidently quite ill. Temperature 103.2° F. The spleen four fingers' breadth below the costal margin, tender and with a sharp medial border. R.B.C. 1,110,000; W.B.C. 850, with only 14 per cent neutrophils and 85 per cent large and small lymphocytes, platelets, 23,900. Blood cultures, Widal, Wassermann and Kahn tests and stool cultures were negative.

After several transfusions the blood picture showed no material improvement, the R.B.C. being 1,700,000, the W.B.C. 350, with 25 per cent polymorphonuclears, 50 per cent small and 25 per cent large lymphocytes, and practically no platelets.

Splenectomy was performed one month after admission; the spleen was found to be soft, boggy and measured 14x8 inches.

Following operation there was a striking improvement of the general condition with a rapid return to normal of the blood picture. In three weeks the R.B.C. were 3,040,000, the W.B.C. 7,600 with normal differential, and the platelets 136,800.

Two months after operation the blood count showed R.B.C. 4,970,000, W.B.C. 28,150 and platelets 987,000. Six months after operation the child's father reports that her general condition is excellent, that she has gained about 15 pounds in weight and has been back in school for the past one and one-half months.

The diagnosis in this case is difficult, the salient features being a severe and persistent aplastic anemia accompanied by a high fever and an enlarged spleen. There can be no doubt, however, that splenectomy was a life-saving measure.

A diagnosis of agranulocytic angina had been made by Dr. George B. Lawson, a thoroughly competent internist, and the patient treated accordingly, but without improvement, and it was at his insistence that splenectomy was done. I have been able to find no observations as to the frequency of splenic enlargement associated with agranulocytic angina, but, when we are dealing with a disease which is credited with a mortality of "at least seventy-five percent" (Cecil), our experience in this case would suggest that splenectomy might offer some hope.

Case 4.—Hospital No. 39677: Susie S., age 10. Six years ago the patient had an attack which was characterized by the vomiting of blood, and a left upper abdominal mass was discovered by the child's mother. The vomiting of blood was repeated at intervals over a period of one and one-half months.

She was then free from any further hematemesis until six days before admission to the hospital; she had always been pale, a little weak, and, as her mother expressed it, "couldn't get around like other children."

On examination, the spleen was found to extend to the midline and downward to the level of the umbilicus. The stools showed gross and microscopic blood, and blood examination showed 1,670,000 R.B.C., with rather marked variation in size and shape;

W.B.C. 2,300, platelets 31,700. After five transfusions, averaging 250 cc. each, the blood picture showed 3,340,000 R.B.C.; 2,850 W.B.C., and 40,800 platelets.

A splenectomy was rendered rather difficult by a network of vessels over the anterior surface and dense adhesions to the tail of the pancreas. The gross appearance and microscopic sections of the spleen, taken in conjunction with the clinical picture, confirm the diagnosis of Banti's disease.

After a few stormy postoperative days, the patient improved rapidly, and one month later showed 4,290,000 R.B.C.; 9,450 W.B.C. and 967,500 platelets.

Following her return home, there was a gradual improvement as shown by check-up when she returned to the hospital for observation six and 12 months after operation.

Two years and seven months after operation her physician reported that she had developed rather profuse hematemesis which persisted for one week. At this time, her blood count was R.B.C. 1,270,000, W.B.C. 3,150, platelets 414,000. The bleeding was readily controlled by three intramuscular injections of 20 cc. of whole blood from her father. Three weeks later the blood count had returned to R.B.C. 3,320,000, W.B.C. 8,550, platelets, 370,000; the differential showing 63% polymorphonuclears, 33% small mononuclears, and 4% transitionals. Her general condition showed corresponding improvement.

Case 5.—Mrs. M., age 23. One and one-half years before admission, the patient first noticed swelling in the left upper abdomen and general weakness. For the past six months, the increase in size of the mass has become more noticeable and presents mechanical interference to stooping or leaning forward.

She has been treated with liver extract, iron and jeculin without beneficial effect. For the past two or three months, she has noticed small hemorrhagic, subcutaneous spots on her arms and fingers. On examination these petechial spots were found still present, and the spleen was enlarged to the midline and downward to the level of the umbilicus. The liver was also palpated, three fingers' breadth below the costal margin.

Blood examination on admission showed hemoglobin 49 per cent, R.B.C. 2,280,000; W.B.C. 2,900, platelets 33,000. After four transfusions of 500 cc. each, over a period of five weeks, the blood picture showed very slight, if any, improvement.

The purpuric spots in connection with the subnormal platelet count were considered to be additional indications for splenectomy, in accordance with the reports of Whipple,[1] Rankin,[2] and Payne.[3]

Splenectomy was then undertaken and presented unusual technical difficulties because of dense adhesions binding the greatly enlarged spleen to the left lobe of the liver and to the cardiac end of the stomach. After separating these adhesions, the very firm attachment to the diaphragm was difficult to understand until it was discovered that the upper pole of the spleen protruded through a hernial opening in the diaphragm for a distance of about two inches. After removal of the spleen, the hernial opening was closed with interrupted chromic gut sutures.

In spite of the occurrence of pneumonia three weeks after operation (flu), gradual improvement was seen, and on discharge, eight weeks postoperative, the blood picture showed 3,570,000 R.B.C., 50 per cent hemoglobin; W.B.C. 5,550, platelets 107,000.

The patient returned for check-up eight months later and showed still more marked improvement.

This case was classified as Banti's disease and was included in the report on account of the association with a diaphragmatic hernia.

Case 6.—Mrs. C. Z. M., age 52, was admitted to the hospital, November 11, 1938, compiaining of a very severe sore throat with ulceration. She had been treated for a similar condition on several previous occasions during the past 20 years, and the throat specialist, who had charge of her, reports that the extent and severity of the throat involvement was unusual. The family physician reports that she has had rather severe arthritis for many years, and that to his knowledge the spleen has been enlarged for 20

years. It is interesting that the patient's father died of some condition associated with an enlarged spleen.

Examination revealed an enormously enlarged spleen. 2,810,000 R.B.C., 54 per cent hemoglobin, 1,550 W.B.C., 16 per cent polys, platelets 272,470.

Under local treatment of the throat and frequent transfusions, the general condition improved greatly, the hemoglobin rising to 100 per cent, with a corresponding increase of red cells; but the leukocytes showed no response whatsoever, being actually lower, ten days after admission, than when she was first seen.

Operation.—November 23, 1938: A splenectomy was performed without great difficulty, as adhesions were not dense. The spleen weighed three pounds fifteen ounces and measured 10x7x3½ inches. A transfusion was given shortly after operation, but it has not been necessary to repeat this, as convalescence has been smooth and uninterrupted.

Microscopic study revealed the surprising fact that this was a tuberculous splenomegaly in spite of the fact that a roentgenogram of the chest was negative.

Study of the blood picture since operation demonstrates the astonishing rapidity with which the leukocyte count returned to normal both as to total and differential count. During this time from 1 to 3 per cent neutrophilic myelocytes and an occasional nucleated red cell were found—giving additional evidence of blood regeneration.

Daily blood counts showed the leukocytes ranging from 750 to 2,850 before operation, while on the second day after operation the W.B.C. was 8,200. At the time of her discharge from the hospital, three weeks after operation, the blood count was R.B.C. 5,290,000 and W.B.C. 6,100.

In this connection, it is interesting to note that the fall in the leukocyte count, following roentgenotherapy for leukemias, is even more rapid, the lowest point being reached one and one-half hours after treatment. These figures were given me by Dr. C. H. Peterson, who followed several cases with counts every 15 minutes.

Case 7.—Mrs. J., age 43, was operated upon, December 26, 1936, for bilateral ovarian cysts. One of these—the left—showed definite penetration of the cyst wall by a cauliflower-like mass of papilloma, and scattered implants of similar nature could be seen in the adjacent peritoneal surfaces and in the omentum. As a few small fibroid nodules were present in the uterus, a supravaginal hysterectomy was performed, and radium implanted in the stump of the cervix.

Beginning one week after operation, deep roentgenotherapy was given. Microscopical sections show the ovarian growth and the omental metastases to be a malignant papilloma.

The patient was seen at frequent intervals and there was no evidence of trouble for ten months. In October, 1937, she began to have pain in the lower left chest in front, suggesting pleurisy. Physical examination and roentgenograms of the chest were entirely negative, until, late in November, a mass was palpated in the splenic region.

Pelvic examination and roentgenologic examination of chest and G.I. tract revealed no evidence of a return of the original ovarian malignancy. Blood picture was that of a secondary anemia. On December 8, 1937, not quite one year from the first operation, a second operation was performed, the following note being made: High left rectus incision. On opening the peritoneal cavity, the fundus of the stomach and the omentum were found plastered over a large mass in the region of the spleen. When the beginning was made in an attempt to strip the omentum off the mass, there was a sudden escape of about two quarts of thin blood stained fluid. After this was evacuated, the finger easily entered a large cavity in the substance of the spleen. Before attacking the tumor, the region of the pelvis was carefully palpated, and no evidence of recurrence of the original tumor could be found. The surface of the liver was also palpated and no

nodules could be felt. Masses of material of very friable character followed the evacuation of this fluid, and were brought out on the sponges with which the fluid was mopped out. The adhesions between the spleen and the surrounding structures were fibrinous in nature and were separated with comparative ease by blunt dissections. The spleen was mobilized and found to be enormously enlarged by the presence of this necrotic mass. With some difficulty, the spleen was brought up, the pedicle divided between clamps and the spleen removed.

On examination, after removal, the spleen was found to contain a definite infiltrating mass, the center of which was necrotic, and had formed the cystic tumor which made up most of the original mass. Grossly, this has the appearance of a malignant tumor. Frozen sections show a definite malignancy, but have none of the characteristics of the original ovarian tumor, which was removed about one year ago.

Microscopic examination of the splenic tumor showed an exceedingly cellular growth suggesting a sarcoma. Tissue was sent to Dr. C. H. Bunting, of the University of Wisconsin, who made a diagnosis of "spindle cell sarcoma, probably myosarcoma."

Some three weeks after operation, a small subcutaneous nodule was found in the lower portion of the left axilla, which was firmly attached to the skin. This was removed under local anesthesia, and microscopically it appeared to be entirely similar in morphology to the splenic tumor, but bore no relationship to the ovarian tumor.

The immediate recovery from operation was good, but soon evidence of recurrence began to appear, abdominal masses were felt, an increasing secondary anemia developed, and the patient died, April 16, 1938, a little more than four months after the splenectomy, No autopsy could be obtained.

This case is presented because of the occurrence of two different types of malignant tumor in the same individual, and because malignant tumors of the spleen, whether primary or metastatic, are relatively rare. As a probable explanation of the rarity of metastasis to the spleen, the work of Dr. Harvey E. Jordan, of the University of Virginia, should be mentioned. He has demonstrated that the spleen does not have afferent lymphatics.

CONCLUSIONS

(1) Attention is called to the rapid rise in polymorphonuclear leukocyte count following splenectomy, and the extremely rapid fall following roentgenotherapy.

(2) Splenectomy is suggested in the treatment of agranulocytic angina.

(3) A case of sarcoma of the spleen is reported in a patient who also had a carcinoma.

I should like to add that the patients operated upon for splenic anemia are all living to-day, and, with the exception of the 73-year-old man, are in good health. The patient with sarcoma of the spleen lived for four months after operation.

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Discussion.—Dr. L. Wallace Frank (Louisville, Ky.): Doctor Jones has presented us with a very interesting series of cases, and I would like to supplement this with a report of two more. In the past 15 years, we have seen

quite a number of surgical diseases of the spleen: some Banti's and some purpura hemorrhagica. We removed one sarcoma in a young woman who died six months later. We have also had cysts of the spleen, and, in 1923, we reported several cases; we saw one hemorrhagic cyst which contained 7,000 cc. of fluid. Another woman, two months pregnant, presented herself on account of a cystic tumor in the region of the spleen. A diagnosis of cyst of the spleen was made but she refused operation.

We have also removed the spleen in one case in which a diagnosis of the splenic type of biliary cirrhosis was made. This girl was 12 years old, with a history of five years' duration of recurring attacks of fever associated with jaundice, enlargement of the liver and gradual enlargement of the spleen. She was operated upon, and we removed an enormous spleen; since then she has had no fever, no more jaundice and the liver is normal. I did not consider it a Banti's disease because it had gone on for five years, with evidence of marked cirrhosis, and there were no gastric hemorrhages.

The two cases I want to mention are instances of miliary tuberculosis of the spleen simulating other diseases. We have seen a third case where a diagnosis was made on roentgenologic evidence, where numerous small calcified areas were found throughout the spleen but no other symptoms existed.

One, a child, age 18 months, had a clinical picture and blood findings of purpura hemorrhagica. The spleen was removed but the child died of intracranial hemorrhage a few hours later. In another, there was slight jaundice and marked anemia. On roentgenologic examination we found an enlarged spleen with many small calcified areas throughout the viscus, with no evidence of tuberculosis anywhere else. There was an increase in the number of reticulocytes and increased fragility of the red cells. These two cases proved, on microscopic examination, to be tuberculosis.

May it not be that these, and other syndromes which we now consider distinct and separate diseases, are the result of different reactions of the spleen to one or more stimuli? In the last cases, the anemia can be accounted for by the fact that there was marked phagocytosis of the red cells in the spleen.

Dr. Hubert A. Royster (Raleigh, N. C.): Of all the organs in the human body, I think the spleen is the least understood, the most often neglected, and is very frequently abused. Its anatomy, its physiology and its pathology have been studied, and yet seldom have we come to any particular conclusions. Its structure, its function in health and its alterations in disease still present puzzles. The general feeling has been that the spleen is the graveyard of the red cells and the birthplace of the white cells. Its relation to bone marrow is not clearly understood. In many cases in which splenectomy is performed, there seems to be no reason for performing the operation or refraining from it.

Since Doctor Frank has recalled cases of cyst of the spleen that he saw, I want to mention three cases which I reported in 1911, all of which happened in seven months' time. The first was a true retention cyst, very large, hanging down so low in the pelvis that it was diagnosed as an ovarian cyst. The second was a hemorrhagic cyst in an already enlarged spleen, in a cotton mill operative, who routinely pressed his abdomen against a machine during his work. The constant trauma had, apparently, produced the hemorrhagic factor. Another case was a huge tuberculous abscess of the spleen in a woman who, four years later, died of pulmonary tuberculosis.

I have learned that the function of the spleen has very little to do with particular diseases of the organ, and its pathology shows few changes in connection with the blood lesions, in cases that have been reported. There seems to be no relation in splenic anemia with any other organ except possibly the

liver. The liver may be primarily involved, but mostly, I think, the whole affair may be regarded as a chronic infection affecting both organs.

That we can do without the spleen is shown by the number of splenectomies performed for ruptured spleens—accidental or spontaneous. Finally, I do not believe we even know what happens when we vent our spleens.

DR. W. LOWNDES PEPLE (Richmond, Va.): I have enjoyed these discussions very much, particularly because of the types of spleen that have been discussed. I want to report this case in order to add it to the recorded cases of spleens lying in the pelvis, and also because I failed to make the diagnosis prior to operation.

Case Report.—Mrs. L. R., age 74, is the mother of two children, age 48 and 45 years, respectively. She is a large, stout woman, apparently in good health. Five weeks prior to my seeing her she had had an attack of upper right abdominal pain with tenderness in that region, gradually shifting to the lower right abdomen.

The blood count was normal and the temperature was 100° F. The urine was normal and other findings were without significance. After a few days' rest, these symptoms subsided, only to be followed by another attack when she left her bed and went about her daily business. Roentgenologic examination was made but the appendix did not fill. Due to certain irregularities in the cecum, the roentgenologist thought that carcinoma of the cecum should be considered. She was admitted to the hospital at Oxford, North Carolina, July 18, 1938, a week prior to my seeing her, and was prepared for operation, should one be indicated.

Physical Examination.—The abdomen was distended, rigid and tender, especially in the right lower quadrant. A mass was detected above the pubis and to the right of the median line. Since a catheter eliminated the bladder and a uterine sound a pyometrium, it was decided that we were dealing with an ovarian cyst on a twisted pedicle, although I could not feel it from below. If this diagnosis proved incorrect, we felt that the only alternative left was an appendiceal abscess well walled-off and wrapped in omentum.

Her blood count was: Red cells 4,250,000, hemoglobin 81 per cent; leukocytes 7,600, polymorphonuclears 74 per cent, lymphocytes 26 per cent. Blood Wassermann and Kahn reactions were negative.

Neither this count, nor the history of recurrent attacks provoked by getting up, seemed to point to the appendix. It seemed to leave a clear field, by exclusion, for a rather high ovarian cyst on a twisted pedicle. Although we could not touch it from below, it seemed to fit better the recurring attacks on standing and moving about. So, with this tentative diagnosis an exploratory celiotomy was performed under ether anesthesia.

Operation.—Through a right rectus incision, extending up to and a little above the umbilicus, a tumor mass was exposed; it lay in the true pelvis and extended for at least three or four inches above the symphysis. It was surrounded by adhesions to the omentum, intestines and bladder, all of which were soft and new, and when these were freed, it was seen that the tumor was the spleen, twisted on a large and congested and edematous pedicle. I could estimate the turns at one and one-half times, and some of the vessels were plainly thrombosed. Since untwisting the pedicle and freeing the spleen might have led to embolism, it was decided to remove it. The pedicle was ligated with No. 2 chromic catgut, and dropped back. Its length, some four inches or more, made this comparatively easy. The stump could be seen to be retracting up to its normal position after this was done. The cecum was carefully examined and revealed no pathology whatever. The appendix, though somewhat atrophic, was quite normal. The wound was closed without drainage. Chromic catgut was used in the peritoneum, muscle

and fascia, and silkworm gut for the skin. There was no tension about the closure and the wound was quite dry.

During the preoperative stay in the hospital, from July 18 to 24, her pulse ran from 70 to 80, and her temperature from 98 in the morning to 100° F. in the evening. She ate well, her bowels moved daily, and the output of urine was satisfactory. Except for a trace of albumin and an occasional hyaline cast, there was nothing in it out of the ordinary.

The operation was completed about 3:30 P.M., having lasted about one hour. She was returned to her room with a pulse of 116. By 6 P.M. it was 120, and her temperature by axilla was 104° F. The character of the pulse was weak and thready but improved with digifolin.

She was given glucose by vein and small amounts of water by mouth. Her pulse ran from 80 to 90, and her temperature from 100 to 102° F. by axilla for the next few days. She was nauseated and vomited small amounts of greenish fluid from time to time. Her bowels moved with enemata and she passed a great deal of gas. Her temperature and pulse gradually decreased, being a little above normal. She began to take nourishment, and by the end of the week seemed to be making a very satisfactory recovery. The silkworm stitches were removed on the ninth postoperative day. The wound was clean and dry.

The next day, following a vomiting spell, the wound opened, with some bleeding. The wound was resutured under light ether anesthesia. There was no pus, no blood clots, and no evidence of peritonitis. The wound had simply failed to heal. Following this, the patient seemed shocked, her temperature went up to 104° F. and her pulse to 120. There was frequent involuntary urination. She was restless and the temperature rose until just before her death, 12 days after operation, it reached 108° F. by rectum. She passed no urine during the last 24 hours.

Postoperative laboratory data showed the red cells dropping to 3,660,000 with hemoglobin 76 per cent. The white cells increased to 15,000 with 89 per cent polymorphonuclears. A few nucleated red cells were found. The urine, which had become dark, showed increasing albumin and casts with a few red cells and pus cells. The day before her death, the urine was semisolid on heating and 50 per cent pus was reported.

Pathologic Examination.—Gross: The specimen consists of a spleen in two parts that combined measure 12x8.8x4.7 cm. There is also a portion of blood clot. The outer surface is reddish and grayish in color and, on section, the cut surface shows at one side an irregular, firm, grayish, tumor nodule 3.8x2.5 cm. A small fragment of similar tissue is seen at another point, just beneath the capsule. Other than these fragments of apparent tumor, the cut surface is dark reddish in color and soft.

Microscopic.—Section of the areas that were thought to be tumor on gross examination showed marked necrosis. Around the necrotic areas there is marked hemorrhage. *Pathologic Diagnosis:* Infarction of spleen.

From the clinical record and finding it on the right side, one would suppose that it was dislodged from its fossa, and the vessels became occluded by twisting of the pedicle which caused the infarction.

COMMENT.—There was nothing in the blood picture in this case to direct attention to the spleen. The rarity of finding it in the pelvis and twisted (about 103 cases reported in the entire literature) would hardly bring it to mind as a possibility. The infarction in the spleen itself and the coagulated blood in the huge veins of the strangulated pedicle, may have produced substances that were toxic, accounting for the high temperature following operation. The ligation of large thin-walled veins, so close to the portal vein itself, must, inevitably, turn some clots directly into the blood stream and on into the

liver. Unfortunately, no postmortem was performed, but I should be much surprised had it not shown marked liver changes if not actual infarction, should one have been made.

Dr. Irvin Abell (ANNALS OF SURGERY, vol. 98, 722, 1933) collected 95 cases from all that were recorded to that date; to these he added two of his own, making 97. In the same journal (ANNALS OF SURGERY, vol. 107, 832–835, May, 1938) Elmer H. Adkins reports a case of his own, and has collected five other cases from the literature, occurring since 1933. This would place the total number at 103 and, with the above case, 104 in all to date.

DISCUSSION.—DR. REGINALD H. JACKSON (Madison, Wis.): Primary neoplasms of the spleen are so exceedingly rare that it would seem a duty to

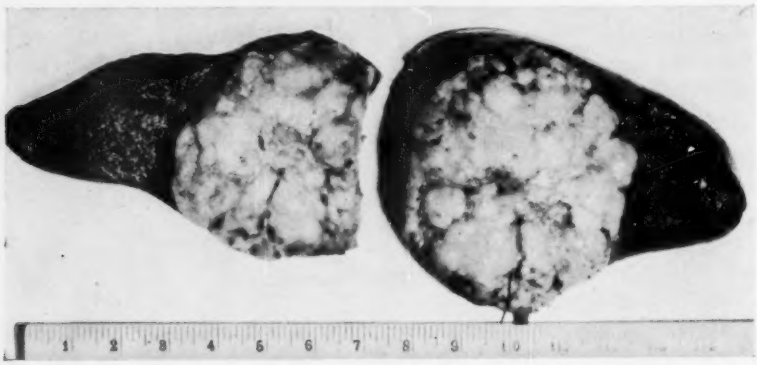

FIG. 1.—Hemangio-endothelioma of the spleen. Preoperative diagnosis of a neoplasm of the spleen, suggested by the absence of the splenic notch on palpation.

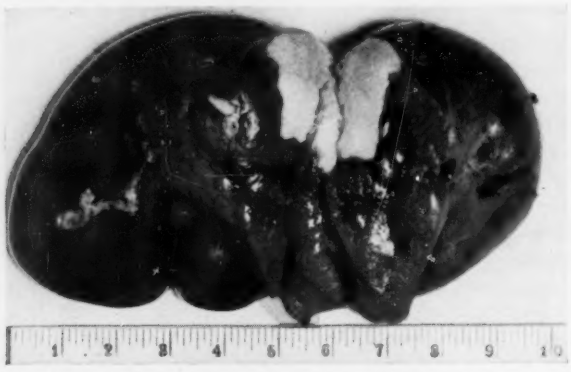

FIG. 2.—Huge infarct on an enlarged spleen, removed from a patient with symptoms suggesting primary tuberculosis of the spleen.

present a recent case of primary hemangio-endothelioma of the spleen. This specimen (Fig. 1) clearly verifies in its topography the admonition that practically the only clue to correct preoperative differential diagnosis between a neoplasm and some other enlargement of the spleen may be that a rapidly enlarging, tender spleen with absence of the splenic notch should excite suspicion as to the presence of a primary neoplasm.

This patient, white, female, age 55, had no particular symptoms aside from

a slowly increasing enlargement of the spleen, accompanied by slight indigestion and tenderness. The absence of the splenic notch suggested a neoplasm of the spleen. This, with the patient's cancer-phobia, invited exploration.

The other case, which I should like to add to Doctor Jones' splendid presentation of unusual spleen cases, brings out the extreme difficulty, at times, of making a correct diagnosis of primary tuberculosis of the spleen.

The specimen (Fig. 2) shows a huge infarct of the spleen. The history, briefly, is as follows: This patient, white, female, age 33, had been bedridden, more or less, for a year with questionable chronic endocarditis. She was in the hospital for several weeks on the Medical Service; repeated blood cultures were negative. The spleen was steadily enlarging, and the question arose as to whether it was a case of primary tuberculosis of the spleen. While the enlarging spleen and the temperature chart suggested it, we felt it was not a distinct clinical picture. The patient asked if we would not perform an exploratory operation. The specimen shown was removed from this woman. It was not tuberculosis; it was an infarct. She improved for several weeks, then there was a return of the endocardial symptoms and she went on to the terminal stage. Autopsy verified the diagnosis of vegetative endocarditis.

DR. R. L. RHODES (Augusta, Ga.): I would like to report an interesting case I saw a number of years ago, before blood transfusions, and even glucose intravenously, were so commonplace. This was a patient with a duodenal ulcer, upon whom we operated, performing a Finney pyloroplasty. Shortly afterward, he started to bleed, and continued to bleed in spite of everything we could do. We got in touch with the family, and his brother came and I told him that the patient was bleeding to death. He informed me that they all bled like that, and they might be comatose for a day or two but got over it. Recalling the old proverb of which Doctor Finney so often reminds us, that "If you can't do any good be sure you don't do any harm," and not knowing anything that would do any good, we felt it wiser to follow the brother's advice and let him alone. Happily, he recovered.

The point is that we must be ever on guard that we be not tempted to overtreat, and do more harm than good. When they have bled so much, reduced the blood volume so low that the blood pressure barely registers, if at all, the bleeding will often stop, and in a few hours evidence of improvement will be noted. This we, not infrequently, see in patients with marked capillary oozing from causes other than hemophilia, and it is a grave mistake to continue to raise the blood volume or the blood pressure, thus keeping the bleeding active.

DR. CHARLES A. VANCE (Lexington, Ky., in closing): With the recital of unusual spleen cases, I would like to add the first one I saw after I started in practice. This was in a girl who came down from the mountains in Kentucky. She had an enormously distended abdomen and we felt what we thought was a spleen. We did not know much about it, but thought it was a case of Banti's disease, so we took it out. She was 16 years old, and it weighed 16 pounds. She got along well and was ready to go home when she suddenly died of a pulmonary embolus. The pathologic report was splenomegaly on the basis of inherited syphilis.

CONSERVATIVE PELVIC SURGERY

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IT IS almost axiomatic that conservative procedures in pelvic surgery require much more painstaking care than more radical operative measures. Resection of an ovary is, as a rule, not as simple as complete removal. Salpingostomy is more tedious than salpingectomy. Myomectomy, properly and completely performed, is ordinarily more complicated than hysterectomy.

Because of the increased technical difficulties and the time consuming nature of conservative surgery, we are often prone to be easily persuaded that oophorectomy, salpingectomy or hysterectomy is best for the patient, thus sparing ourselves the time and trouble involved in an attempt to save these structures. There is also a rather general feeling that certain conservative operations upon the pelvic organs are attended by greater danger and that convalescence is more prolonged and stormy. This may, to some extent, be true, but it may be due to the fact that we have not given enough care and attention to our technic. The fault may not always be in the operation *per se* but in the manner in which it is performed.

Anyone essaying to do pelvic surgery should be willing to give the time and study to each individual case as indicated. All angles must be considered. The age of the patient, her social and economic status, her physical and psychologic make-up, her desire for children, *etc.* These various phases should be thought out and discussed with the patient prior to the operation and her reaction studied. There is also a medicolegal aspect which makes previous discussion important. Religion may play a part. It is often surprising what can be safely accomplished in a conservative way if we but make the effort. Of course no one would advocate attempting to save a hopelessly diseased tube, but many times restoration of function of a crippled tube may be carried out by a plastic operation. Removal of the opposite tube in a case of tubal pregnancy has been preached. This might, on occasion, be indicated, but it is far too radical as a routine measure. I have known many women who have had several children following tubal pregnancy. One, I recall, has had five children. When both tubes have to be sacrificed, the psychologic effect of being able to truthfully assure the patient that there is still a possibility of pregnancy may, at times, mean something. The Estes[6] operation of fixing the ovary to the uterine cornu or Tuffier's[5] and later Pani's[8] procedure of implanting the ovary through the uterine wall are to be considered. Pregnancies have been reported following each of these technics. Quite often it is possible to retain a considerable portion of normal healthy ovarian tissue by resection of a badly involved ovary when the first inclination would be complete extirpation. The fact that the other ovary is sound is not a legitimate reason for complete removal of an involved ovary. Conservation of the ovary when hysterectomy is performed is advisable whenever possible. Graves for-

merly claimed that the ovaries undergo degenerative changes and that function soon ceases when the uterus is removed. This, I believe, is open to question.

If the uterus would prove more of a liability than an asset it would be foolish to attempt to save it, but many women would rather gamble on the chances of another operation than face the realization that there would be no more menstrual flow. There is a certain psychic shock in this to some women and it is quite difficult, or even impossible, to convince such individuals that they have not been thus unsexed. Common sense, to be sure, must be used in all these problems.

Uterine myomata or fibroids do not always call for operation, and when operation is indicated hysterectomy is not necessary in many instances. Even in the presence of tumors of considerable size it is remarkable what results can sometimes be obtained by myomectomy when it seems desirable to save the uterus. A uterus that, at first glance, may seem beyond redemption can often be salvaged and restored to a more or less normally functioning organ. The operation of myomectomy was formerly regarded as being attended with greater danger than hysterectomy. If properly performed, and special attention be given to hemostasis and neat closure of the uterine incision, the risk is little if any greater. I have heard surgeons counsel against removal of the appendix when myomectomy was performed for fear of possible contamination. Others are in the habit of placing a "tell-tale" drain when doing a myomectomy. These precautions are probably based on theoretic rather than actual facts and the dangers have been magnified.

Myomectomy does require time and additional care. Control of bleeding, avoidance of mass tying as much as possible, careful approximation of the peritoneal surfaces and stitches tied *not* too tightly are important technical points. Unless the fibroid is frankly submucous, opening into the uterine cavity is not so hazardous. There is possibility of endometrial implants when the cavity is invaded but this is remote. I have seen two such occurrences following myomectomy. One of these patients had a myoma or fibroid as large as an average grapefruit which was situated in the anterior uterine wall and which involved the wall of the bladder. It was removed with considerable difficulty. Later on this patient developed a painful, tender nodule in the anterior culdesac which produced intractable bladder symptoms. She became pregnant and had to have a therapeutic abortion because of the pain. At the second operation I found an endometrioid nodule between the uterus and the bladder and involving the bladder wall, so that a bladder resection was necessary. When the bladder wall is intimately attached to a fibroid, it is sometimes better to resect that portion of the bladder than to carry out a dissection. This particular case is included in this discussion because it illustrates some of the poor results of conservative surgery. A myomectomy was performed at the first operation because of the urgent request of the patient that her uterus be saved if possible.

If there is much scarring of the uterine wall, particularly on the posterior

surface, following myomectomy, an omental transplant is an excellent procedure. I have employed omental grafts a great deal both after myomectomy, and for covering raw surfaces in other operations, and have found them quite satisfactory. Just recently I had occasion to perform a cesarean section upon a patient upon whom I had performed a multiple myomectomy about five years previously, at which time I had employed an omental graft. This graft could still be seen as a veil over the posterior wall of the uterus and there were no adhesions. This was the second pregnancy since the myomectomy. There were no other tumors of the uterine wall apparent. Many other women upon whom I have performed a myomectomy have borne children, some of them having had several pregnancies.

Another point that I would like to stress is a conservative attitude toward operative necessity. How many times we see a patient who has given up to the surgeon a so-called diseased ovary when the cause of the symptoms was probably stricture of the ureter. Careful study and investigation and, I might add, an open mind would avoid many such operations. A cystic ovary is not always an indication for surgery. Many of these are transient cysts and will later disappear. Nor does lateral pelvic pain and tenderness of necessity spell disease of the tube or ovary, but all too frequently this does spell doom for these structures. Again I would urge a thorough investigation of the urinary tract. Fibroid tumors which are symptomless, the "silent fibroids," do not usually call for operation. Furthermore, in women at or approaching the menopause who have uterine tumors which are producing symptoms that do not necessarily demand major operation, radium or roentgenotherapy may frequently avoid the danger, inconvenience and expense of the major procedure. And again conservative handling of a pelvic inflammatory condition may restore the patient to normal health and save her from a mutilating operation.

I am not giving any statistical reports. This is merely a plea for a more conservative consideration of gynecologic problems, especially in the operative line. To be sure, all possibility of malignacy must be eliminated in every case. Upper urinary tract changes so often associated with pelvic pathology must not be overlooked. (Kretchmer's[4] studies show the frequency of such changes.) I do not advocate an extreme position. One must keep an open mind and use common sense. Be conservative within justifiable limits, and temper conservatism with reason.

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DISCUSSION.—DR. E. H. RICHARDSON (Baltimore, Md.): I want to say a few words in regard to Doctor Shallenberger's excellent paper, and perhaps review one or two points that may not be familiar to general surgeons who do not habitually read gynecologic literature closely. For many years, there have been some members of the medical profession who believed and taught that it might not be worth while to save the ovaries when hysterectomy must be performed. Quite a little controversy was started when the late Doctor Graves published an article supporting this contention. At that time I reviewed the literature and replied to his paper. I shall not repeat the results of that study now, but there can be no question whatever that the overwhelming majority of American gynecologists to-day feel that his thesis was not established, but, on the contrary, that the ovaries should be preserved whenever it is possible to do so.

Perhaps many general surgeons may not be fully aware of the fact that in many normal women the inner third of the ovary receives its circulation through a rich anastomosis in the mesosalpinx between the terminal branches of the uterine and the ovarian arteries. When an attempt is made to save the ovary in conditions requiring salpingectomy one should, therefore, cut across the mesosalpinx just as close to the tube as possible, so as not to obtain subsequent cystic degeneration of the ovary. Certainly most of us have had many opportunities to observe women who have not had their menopause for many years following hysterectomy, even with only one ovary having been preserved. Just recently, I had an opportunity during a celiotomy, performed 15 years subsequent to hysterectomy, to examine a retained ovary. Not only was it normal in all respects, but exhibited a fresh corpus luteum.

Most of us, like myself, were taught that a woman is born with all the ova she will ever possess. Williams' Text-book said the estimated number was 100,000 ova in each ovary and that by the time puberty is reached they had been reduced to about 30,000. That teaching was universally subscribed to for many years but has now been completely upset. For recent work has shown that in most of the ordinary mammals, *e.g.*, the dog, the guinea-pig, the cat, the rat, the opossum and the monkey, with every estrus period there is development of a great many new ova from the germinal epithelium on the surface of the ovary—in the dog 500 or 600. This has been shown to occur to some extent also in the human. Even if it is possible to save only a small portion of an ovary, therefore, it not only preserves menstrual function but might also provide a possibility of subsequent childbearing, owing to the fact that ovogenesis occurs with each menstrual cycle in women, as happens in the lower animals.

DR. CURTIS TYRONE (New Orleans, La.): I want to endorse what Doctor Shallenberger said. We have always tried to save the ovaries and uterus. We reviewed some cases and found that about 30 per cent later became pregnant. In this series of cases, there were three tumors on which the report came back of sarcomatous change. Two of these women became pregnant, and I know they have gone along without any evidence of recurrence, so we do not need to fear, in removing a fibroid tumor on which we get such a report, that the patient is inevitably doomed.

Dr. W. L. Estes, Jr. (Bethlehem, Pa.): Doctor Shallenberger has been kind enough to refer to the operation devised by my father and still practiced in our clinic—ovarian implantation. I believe that all those who have heard the plaints or received the pathetic letters of women who have lost both tubes, asking whether some other operation cannot be performed so that they can become pregnant, will realize the great wisdom in Doctor Shallenberger's plea for conservation in pelvic surgery.

I reported before this Society, about four years ago, our experience up to that time with the operation we designated "Ovarian Implantation." In this operation, after a bilateral salpingectomy has been performed, the ovary is implanted into the horn of the uterus, so that there may be a possibility of ovulation directly into the uterine cavity, and, thus, to permit the opportunity for pregnancy to occur. We reported 40 cases, four of whom had become pregnant. Two had had miscarriages and two had borne full-term children. One woman, operated upon in 1912, had three full-term children and one miscarriage following the operation. Approximately 20 years later, she was reoperated upon for a large uterine fibroid, and both the uterus and the implanted ovary resected. Examination of the specimen removed showed a continuation of the uterine cavity up through the horn to a cystic dilatation in the stroma of the ovary itself. This would seem to explain how repeated pregnancy had been possible. Recently, in performing this operation, we have made the opening into the uterine horn sufficiently large so that the surface of the ovary is placed in contact with the margins of the uterine mucosa or endometrium, with the hope that there will be an area of ovarian surface which will form a part of the lining of the uterine cavity. It has been definitely shown by Tuffier that the ovary should not be placed within the uterine cavity. We have operated upon five women with this latter type of operation, two of whom have had miscarriages. The incidence of pregnancy, therefore, following this operation, is not high, but operations such as this can be employed to give some hope to these childless women when conservative surgery has been practiced, as Doctor Shallenberger has so well urged.

Dr. G. L. Hunner (Baltimore, Md.): I would like to say a word about Doctor Shallenberger's excellent presentation. In the early days of this century, when myomectomy was first gaining favor, we saw too many of these patients develop toxic symptoms and a high temperature immediately after operation, and some of them promptly died. Others developed an abscess of the uterine wall and required subsequent drainage. A. J. Ochsner, of Chicago, thought these stormy symptoms followed strangulation of tissue by tying of ligatures too tightly. Observations in our clinic led us to believe that these early toxic symptoms were due to chemical changes, and sometimes infection, in blood which accumulated in the depths of the uterine wound. In other words, the hasty surgeon failed to use enough buried sutures to eliminate all dead space. I have had good results in these cases by using enough sutures of No. 1 plain catgut in the depths of the wound to obliterate all dead space; and, in addition, when excising very large myomata, I deliberately provide dependent drainage. If some of the uterine mucosa has not come away with the large tumor, I cut a window, 2 to 4 cm. in diameter, in the mucosa, thoroughly dilate the cervix from above, and push a strip of washed iodoform gauze down into the vagina, leaving enough gauze to loosely fill the uterine cavity. This provides drainage for blood or serum during the first 24 to 48 hours, after which the gauze is removed per vaginam.

Dr. W. F. Shallenberger (Atlanta, Ga., in closing): I did not mention the possibility of ruptured uterus after myomectomy in subsequent pregnan-

cies, and this always has to be considered. It is well to inform the patient of such contingency, so she will be on her guard if she passes from under your care.

Another thing I would like to mention is the indiscriminate use of endocrine substances in women. I do not know that the administration of all these substances causes any harm but I have talked with several gynecologists and it seems to be the opinion, from what I can learn, that endometriosis is on the increase. Whether there is any connection I do not know, but that has to be taken into consideration. Probably nine out of ten women, who have been under the care of a physician prior to the time they consult me, if they have had any menstrual trouble, have been pumped full of antuitrin S and theelin or what not, and I think there might be some possible damage from the indiscriminate use of these substances.

GENITAL TUBERCULOSIS AND PREGNANCY

WITH SPECIAL REFERENCE TO TUBAL GESTATION

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THE relationship between genital tuberculosis and pregnancy has been the subject of several careful clinical studies. These have appeared chiefly in the French literature. Our original contribution has to do with the relationship between genital tuberculosis and tubal gestation.

In the literature, one occasionally meets the statement that genital tuberculosis is one of the causes of tubal pregnancy. We have had no reason to investigate this question till recently, when one of us operated upon a young woman who had these two conditions. This prompted us to investigate this question and see how often these two conditions were associated with each other. It also caused us to study the incidence and effects of intra-uterine pregnancy upon women who had genital tuberculosis.

Incidence of Tubal and Abdominal Gestation With Genital Tuberculosis.—In January, 1938, one of us operated upon a young woman who had a ruptured tubal pregnancy and tuberculosis of the fallopian tubes and endometrium. We diagnosed the tubal pregnancy before operation; as is often the case, however, we did not suspect that the young woman had genital tuberculosis, nor did we recognize the condition on the operating table. The diagnosis of tuberculous endometritis and salpingitis was made in the pathologic laboratory.

We shall pass over the details of this unusual case, as it is being reported elsewhere. It is worth observing, however, that the history suggests that this young woman had had tuberculosis since childhood, when her father, a physician, suspected its presence and looked for it, but could not be sure of it.

This case is unusual, in that it is the only instance in this hospital in which these two disorders have been associated. In numerous other instances, tubal gestation has been associated with almost every other gynecologic disorder, but this is the only case in which it has been found in conjunction with tuberculous endometritis and tuberculous salpingitis.

We then looked through the American literature and could find no similar case, although we did find an occasional statement that tubal pregnancy was at times caused by tuberculous salpingitis. In the foreign literature, there are eight recorded cases.

In addition to these eight (including ours, nine) cases of tubal gestation, there have been eight remarkable cases in which the gestation sac lay completely or partly free in the abdominal cavity. In three of these cases of abdominal pregnancy with bilateral tuberculous salpingitis, celiotomy revealed the gestation sac cradled in the fimbria of one tube (Acconi,[5] Alexander and

Moszkowicz,[6] and Kroener[7]). Schröder and Rau,[8] Shober,[9] Mossa[10] and Therkelsen[11] have described four cases in which the gestation sac was found entirely outside the tube and uterus, lying in the pelvis, adherent to the broad ligament, between the ovary and tube. In some of these cases, the corpus luteum of pregnancy was found in the opposite ovary, indicating external migration of the ovum. Werhatzky[12] reported an abdominal pregnancy of four months, in a patient with tuberculous salpingitis. The fetus measured 16 cm. in length and was dead when the celiotomy was performed.

The ratio of abdominal gestation in this series of pregnancy is amazingly high, for abdominal pregnancy is ordinarily very rare. Does this indicate that the ovum is unable to get into the tube, perhaps not farther than the fimbria, and is there fertilized? We can only speculate on the several possible explanations that come to one's mind.

In general, therefore, extra-uterine pregnancy is very rare in the presence of tuberculous salpingitis. In all, including this case, we can find only 17 cases in the literature. It is noteworthy that in eight of these, the gestation sac was completely or partly free in the abdominal cavity, an unusually high ratio of abdominal pregnancy.

On the basis of this experience, therefore, we think that it would be wise to correct the idea that genital tuberculosis and tubal gestation are frequently associated. As far as we can discover, this is one of the rarest combinations seen in gynecology.

The reason is probably clear: Tuberculosis is an invasive, destructive disease. In the vast majority of cases, the dense scarring, caseation and tissue destruction produced in the fallopian tubes probably completely destroy the possibility of any future function.

Incidence of Intra-Uterine Pregnancy and Genital Tuberculosis.—How often is intra-uterine pregnancy associated with genital tuberculosis? What effect does gestation have on the disease? Is it wise to try to conserve the reproductive function in women with genital tuberculosis?

Obviously, any conclusions reached must be based on proved facts. The diagnosis of genital tuberculosis must have been proved by celiotomy or endometrial biopsy, at least. The treatment must have been conservative, with preservation of the reproductive organs. To get such records, we have to go to sanitaria where, for years, all forms of tuberculosis have been treated by heliotherapy and similar physical agents. The French school of gynecologists have always been particularly interested in genital tuberculosis and theirs are the most instructive records we possess.

In the first place, the incidence of pregnancy after genital tuberculosis is rare. This is due chiefly to the destructive effects of the disease; at times, it may be due to uterine hypoplasia, according to the French school. Uterine hypoplasia has not been observed as frequently by American observers as it has been in France.

There are two types of pelvic tuberculosis that have been followed by intra-uterine pregnancy, in which the pregnancy may be carried to term without any puerperal complications. These are: First, tuberculous peritonitis

without endosalpingitis; and second, rare instances of tuberculous endometritis without deep or lasting damage to the tubes or uterus.

Incidence of Intra-Uterine Pregnancy Following Tuberculous Peritonitis.—This group is really outside our consideration, because in it the chief lesion is really a diffuse tuberculous peritonitis. The genital lesion is often limited to the serosa of the fallopian tubes and uterus. If the fimbria or endosalpinx is affected, it is secondary to the serosal and peritoneal involvement and may be very slight. Hence, these are not primarily cases of tuberculous salpingitis.

Rollier, of Switzerland, has collected the records of several women who, after recovering completely from tuberculous peritonitis, conceived and bore healthy children, without any puerperal complications or exacerbations of tuberculosis. Many of us have had occasion to perform celiotomies upon women years after they recovered from tuberculous peritonitis, and have then discovered no trace of the former infection. There is no reason, therefore, why some of these patients should not conceive without undue risk.

Incidence of Intra-Uterine Pregnancy Following Tuberculous Endometritis.—The second group in which pregnancy has been known to go to term normally without complications includes a very few cases of tuberculous endometritis, either without salpingitis or with very slight tubal involvement. Such cases are discovered occasionally by examination of uterine curettings, the indication for the curettage being sterility, leukorrhea or some similar condition. Now that endometrial biopsies are being made more regularly in the study of sterility, unsuspected and asymptomatic tuberculous endometritis is being discovered more frequently.

After recovering from endometrial tuberculosis of this type, a few women have borne children without puerperal complications, atlhough this is a rare event. Rollier has observed one or two such cases. Cuzzi[3] tells of a woman who was curetted 14 times over a period of years. At each of these curettages, the specimen of endometrium showed tuberculosis. She was then given heliotherapy. Later she conceived and bore a child normally, without any exacerbation of her old trouble. Schroder[4] reported two similar cases of endometrial tuberculosis, diagnosed by curettage, and followed some years later by normal pregnancy. In these cases, the endometrium contained areas that were healthy and of normal functional activity, in addition to tuberculous foci.

In these cases, the only treatment was curettage, sanitarium treatment and heliotherapy. We can recommend sanitarium treatment and heliotherapy without reservation, but would hesitate to perform repeated curettages upon patients with tuberculous endometritis. There would be the unavoidable risk of disseminating the disease, just as in streptococcal and gonorrheal infections. No one can deny, however, that in a very few cases the procedure has been harmless and has also been followed by normal pregnancy.

Incidence of Intra-Uterine Pregnancy After Tuberculous Endosalpingitis.—If there has been a true endosalpingitis, sterility is practically invariable and usually permanent. Very rarely has conception followed tuberculous salpingitis. How often has this occurred? What has been the consequence of the gestation?

Feuillade[2] has collected from the literature all authentic and available cases of intra-uterine pregnancy in women who have had genital tuberculosis. He has divided them into two groups: First, those that conceived following conservative surgical treatment and after they had recovered completely from the disease; second, those who conceived (intra-uterine) before complete recovery from the genital tuberculosis.

Feuillade found only seven cases in the first group, and we have been able to discover no more. In all of these, the diagnosis was established by celiotomy or curettage. Two of these belong to the group already referred to—tuberculous peritonitis or endometritis with only slight if any involvement of the tubes. In the rest, the salpingitis was definite. All of these women conceived. One aborted; six carried pregnancies to term, although the first pregnancy may have ended prematurely. Only one patient in the seven had any puerperal complication.

Included in this group is the very remarkable case operated upon by McNaughton-Jones. His patient had a unilateral tuberculous pyosalpinx which he removed. She subsequently had several healthy babies without complication.

An invariable feature in this group is that, after recovery from tuberculous salpingitis, many years passed (five to ten or more) before any of these women conceived. From this study, it is also evident that one can count on the fingers of his hands, the number of women who have borne children normally after having had tuberculous salpingitis.

Incidence of Intra-Uterine Pregnancy Before Recovery From Genital Tuberculosis.—There is a marked contrast between this group of seven cases, which we have just considered, and the following group of 17 cases, in which the pregnancy developed before the patient had recovered completely from genital tuberculosis.

Feuillade has collected 17 instances in which women had an intra-uterine pregnancy before they had recovered completely from genital tuberculosis. The consequences were disastrous both to the child and the mother.

Only five of the 17 pregnancies went to term. At least three of the five living babies died of tuberculosis within a few months, leaving at most only two babies in 17 pregnancies.

The maternal loss was equally serious. Sixteen of the 17 mothers had serious exacerbations of tuberculosis, usually in the pelvic organs. Eleven mothers died; six recovered. Of the six who recovered, four required radical pelvic operations under very adverse circumstances. The usual lesions of tuberculosis were in the pelvic organs, the peritoneum, lungs, and the miliary type.

A tuberculous puerperal infection runs a course which is rather different from the more fulminating streptococcic variety. It is slower in onset, but is usually fatal in from six to eight weeks.

Finally, another rather interesting feature is presented by studying genital tuberculosis. In our cases, Greenhill[1] found that about 12 per cent traced the onset of their symptoms to childbirth, miscarriage, or induced abortion. Does

this indicate that in a few of these cases, perhaps, there may have been a dormant or incipient genital tuberculosis which was activated by the pregnancy? We can only speculate concerning the significance of this observation.

SUMMARY AND CONCLUSIONS

Genital tuberculosis usually makes conception impossible.

Patients have occasionally borne healthy children without puerperal complications, if the genital lesion consisted merely of a peritoneal involvement or of endometritis, with very little, if any, tubal involvement. This latter is a very rare type of genital tuberculosis.

True tuberculous endosalpingitis, however, almost invariably precludes the possibility of future conception. The literature reports only 24 authentic cases of intra-uterine gestation following tuberculous salpingitis. Seven of these conceived years after apparently complete recovery from the infection; six carried their pregnancies to term, five of them had normal puerperia. In 17 cases, the pregnancy came before complete recovery from the genital tuberculosis. Of these 17 women, only five carried their pregnancies to term, and three of these five babies died of tuberculosis within a few months. Of these 17 mothers, 11 died of exacerbation of pelvic tuberculosis, with the usual dissemination. It is thus evident that one can count on his fingers, the number of live babies born to women who had tuberculous salpingitis.

Tubal gestation is even more rare after genital tuberculosis. In about one-half of the cases of extra-uterine pregnancy that are associated with tuberculous salpingitis, the ovum fails to find nidation in the tube, and develops as an abdominal pregnancy. Genital tuberculosis is one of the rarest antecedents of tubal gestation.

From this, it is clear that it is unwise to try to save the reproductive function in women with genital tuberculosis. According to the pathology of the disease, in every case one should perform a bilateral salpingectomy; in about one-half of them, hysterectomy; and in about one-third oophorectomy will be necessary.

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INJURY TO URETERS DURING PELVIC OPERATIONS

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SINCE January 1, 1915, on the Gynecologic Service at Barnes Hospital, we have had 15 cases of ureteral injuries. These injuries developed during the course of pelvic operations and include all forms of injuries to the ureters such as crushing, cutting, ligating, etc. There were a few other cases of ureteral injury that were admitted on the Genito-Urinary Service and not included in this series of cases. I also saw a few cases in consultation in other St. Louis hospitals. There will be published shortly a detailed case history report of 14 of these cases of injured ureters. Therefore, in this presentation, I shall report only a brief abstract of these cases and add one other, making in all 15 cases.

From January 1, 1915, to November 1, 1938, in the Gynecologic Service at Barnes Hospital, 3,144 hysterectomies were performed for various reasons. Of this number 944 were complete abdominal hysterectomies, 128 were complete vaginal hysterectomies and 2,072 were abdominal supravaginal hysterectomies. During the course of these operations one or both ureters were knowingly injured by clamping, cutting, tying or interfering with the circulation in some manner in all the cases.

Most gynecologists regard operative injury of the ureter as exceptional, and nearly all are in accord in believing unilateral injury fairly common, and bilateral injury exceedingly rare. They describe ureteral injury as the most common accident in doing pelvic work.

ABBREVIATED CASE REPORTS

Case 1.—On May 11, 1916, a supravaginal hysterectomy and double salpingo-oophorectomy were performed for myoma of uterus. Both ureters were ligated. On the fourth postoperative day, the abdomen was opened and the ureters were deligated. The patient died on the thirteenth postoperative day from general peritonitis and septicemia.

Case 2.—On September 22, 1919, a vaginal hysterectomy and double salpingo-oophorectomy were performed for early cancer of the cervix. Thirty days postoperative, a left ureterovaginal fistula formed. Eight months later, urine ceased to dribble from vagina and cystoscopic examination revealed no function of left ureter, with a dead kidney. Right kidney was in good condition.

Case 3.—On April 16, 1920, a complete abdominal hysterectomy and double salpingo-oophorectomy were performed for chronic cervicitis, retrodisplacement and cystic ovaries. Twelve days after the operation, a right ureterovaginal fistula developed. Two months later a right nephrectomy was performed for a pyonephrosis.

Case 4.—On June 8, 1920, a complete abdominal hysterectomy and double salpingo-oophorectomy were performed for myoma of uterus. Four days after operation, a left ureterovaginal fistula developed. Patient refused further care and left the hospital. She never returned.

Case 5.—On July 14, 1921, a complete abdominal hysterectomy and double salpingo-

oophorectomy were performed for an early cancer of the cervix. Eight days after operation, a right ureteral fistula developed. Two months later, the right ureter was transplanted into the bladder and three days after this operation an abdomino-ureteral fistula developed which was present for 30 days, at which time urine ceased to flow from the fistula, and the patient was discharged. Nine and one-half years after the first operation, the patient was cystoscoped and it was found the kidney on the right side was dead. The left kidney was functioning perfectly.

Case 6.—On September 4, 1928, a supravaginal hysterectomy and double salpingo-oophorectomy were performed for myoma of uterus. During the operation, it was known the right ureter had been severed near the bladder. It was immediately transplanted into the bladder. Ten days later it was found that the right ureter was not functioning and a right pyonephrosis was present. Thirty days after the original operation a right nephrectomy was performed.

Case 7.—On August 13, 1931, a complete hysterectomy and double salpingo-oophorectomy were performed for chronic pelvic inflammation. Seventeen days after operation, a right ureterovaginal fistula developed. Three months later a right nephrectomy was performed for right pyonephrosis.

Case 8.—On January 4, 1930, a complete abdominal hysterectomy and salpingo-oophorectomy were performed for carcinoma of corpus uteri. Patient had a double uterus. Thirty-six hours after operation patient died from acute dilatation of the heart and at autopsy it was found that the left ureter had been ligated.

Case 9.—On May 27, 1930, a complete abdominal hysterectomy and double salpingo-oophorectomy were performed for carcinoma of corpus uteri. Twelve days after operation, the patient died and at autopsy it was found that the right ureter had been ligated. The cause of death was massive collapse of both lungs.

Case 10.—On June 13, 1933, a double salpingo-oophorectomy was performed for large bilateral ovarian cysts. Five days after operation, a left uretero-abdominal fistula developed. Six weeks later an end-to-end anastomosis of the left ureter was performed with excellent results.

Case 11.—On September 7, 1934, a supravaginal hysterectomy and double salpingo-oophorectomy were performed for myoma of uterus. The patient died immediately after operation and the postmortem findings were pulmonary atelectasis (bilateral), fibrous adhesions in right pleural cavity, horseshoe kidney and ligation of the left ureter.

Case 12.—On June 25, 1936, a complete abdominal hysterectomy and double salpingo-oophorectomy were performed for myoma of uterus. Five days after operation, the patient died from acute peritonitis. Autopsy showed the right ureter had been ligated.

Case 13.—On June 15, 1935, a supravaginal hysterectomy and double salpingo-oophorectomy were performed for myoma of uterus. Eight weeks after operation, the patient died. The autopsy revealed pyelonephritis, ileo-ureteral fistula and bacterial endocarditis. The right ureter had been ligated.

Case 14.—On September 5, 1935, a complete abdominal hysterectomy and double salpingo-oophorectomy were performed for chronic pelvic inflammation. Two days after operation, a cystoscopic examination revealed that the right ureter had been ligated five centimeters from the bladder. A right nephrostomy was immediately performed. Twenty-four days after the nephrostomy the right ureteral catheter passed up to the kidney, and within a few days the nephrostomy wound closed.

Case 15.—Hospital No. 62076: Mrs. B. H., age 40, was operated upon for myoma of uterus (intraligamentary), June 24, 1937. A supravaginal hysterectomy and double salpingo-oophorectomy were performed. The postoperative course was stormy and two days after operation a uretero-abdominal fistula developed. She refused another operation and after three weeks' stay in the hospital was discharged with the uretero-abdominal fistula still present. She has not been heard from since.

I believe the reason I am able to report such a large series of these cases is

that at the Barnes Hospital, most of the deaths come to autopsy and our pathologist has been instructed to pay especial attention to the ureters when performing autopsies on gynecologic patients. In our series, six cases of ligated ureters were found at autopsy. In none of the cases was injury to the ureters suspected.

Of the remaining nine cases, two refused any form of treatment and were lost track of. One was cured spontaneously by death of the kidney on the affected side; two were cured by nephrectomy for pyelonephrosis; two were cured by nephrectomy after transplantation of the ureter into the bladder had proven unsuccessful; one was cured by end-to-end ureteral anastomosis; and one was cured by nephrostomy.

I am sure this serious accident during pelvic surgery is more common than one realizes, and if the operator will thoroughly investigate the genito-urinary tract when his pelvic surgery cases run a stormy postoperative course, he will find some serious ureteral damage in many unsuspected cases.

It is difficult to outline any specific treatment for an injured ureter, as no one investigator has had enough personal experience with the condition to draw any detailed conclusions. I have encountered 15 cases, and have followed the outcome of all of them. It is interesting to note that the 15 injuries were inflicted by 15 different gynecologists. From my experience with these 15 cases, I would like to outline a procedure to follow when this condition is encountered.

In selecting the type of operation for the cure of this condition, one must consider deligation, nephrostomy, uretero-ureteral anastomosis, ureterovesical anastomosis, ureteral transplant into skin, bowels, *etc.*, ligation of ureter and nephrectomy. The aim of any operation should be to preserve the kidney and not to destroy it, unless nothing else can be done.

At the time of operation, if it is discovered that one or both ureters have been ligated, the proper treatment is to deligate as soon as the condition is recognized. If one or both ureters have been severed, a uretero-ureteral anastomosis should be performed by one of the various accepted methods. Of course, if the patient is in bad shape and only one ureter is damaged, a ligation may be performed, which may cause death of the kidney. The uretero-ureteral anastomosis operation is the one of choice.

If it is discovered that the ureter has been crushed by a clamp, the injury should be carefully examined and, if it is determined to be severe, end-to-end anastomosis should be performed in order to prevent a ureterovaginal or uretero-abdominal fistula. If the injury is not severe, circulation may be restored and healing take place without a fistula forming. I have performed an end-to-end ureteral anastomosis upon two cases using the technic first described by Curtis. A ureteral catheter is passed into the cut ureter and the lower end brought out through the bladder and urethra, the two ends of the ureter are sutured together, taking care not to penetrate the lumen of the ureter with the sutures. A second ureteral catheter is placed in the ureter above the point of the anastomosis through a small slit and passed up to the

pelvis of the kidney so as to divert the passage of the urine away from the regular course. The catheter is brought out through a stab wound in the flank. After ten days both catheters are removed. The catheter apparently splints the cut ureter and by rerouting the urine away from the site of repair the ends of the ureters do not have to be water tight. They heal amazingly quickly.

Several days after operation. If both ureters have been ligated, and this is not discovered until two to four days after operation, the condition is a serious one. The patient ordinarily has a complete anuria with uremia and something very urgent must be done. Two things are to be considered: (1) Deligation of the ligated ureters. (2) Nephrostomy. Not enough cases have been handled by either method for one to draw any definite conclusion. Of course, deligation is the operation of choice, if the patients' conditions are such that they can withstand a serious operation. It must be remembered that uremia is present and ordinarily the patient is a poor operative risk; searching for the ligated ureter is not easy; also, after locating it, can the patient stand a uretero-ureteral anastomosis or whatever type of operation one elects? On the other hand, is nephrostomy the choice? Certainly, it seems to be the best operation when the patient's condition is grave, as it can be quickly carried out, and when the patient's general condition improves, if necessary, then deligation may be attempted.

Ureteral Fistulae.—These are the most common sequelae of ureteral injury; usually occurring from three to 12 days after operation, and may be either abdominal or vaginal, the latter being more common than the former. A cystoscopic examination with ureteral catheterization should be performed in order to locate which ureter is not functioning into the bladder, and also to determine the condition of the other kidney. It is probably best to wait from one to six months after the primary operation before attempting operation for the cure of the ureteral fistula, as sometimes, from the scar tissue contraction, the fistula is cured spontaneously. Usually, in such cases a hydronephrosis develops, with infection and death of the kidney, but if operation is attempted too early after the formation of the fistula, the patient is not in a suitable condition to withstand the operation, whereas, after one to six months much better results would be obtained.

CONCLUSIONS

(1) Ureteral injury is a surgical complication that is fairly common.

(2) Many cases of unilateral ligation follow pelvic operations and are not recognized.

(3) The most common sequelae of ureteral injury are abdominal and vaginal fistulae.

(4) A certain number of deaths following pelvic surgery are the result of ureteral injuries.

(5) Nephrostomy and uretero-ureteral anastomosis are the operations of choice. Nephrectomy is commonly performed. Nephrostomy is a life saving operation and should be performed in all cases of double ureteral ligation, when the patient's condition is grave.

(6) Any operation performed for an injured ureter should be one to preserve normal ureteral and kidney function.

DISCUSSION.—DR. H. J. BOLDT, White Plains, N. Y.: I have been exceedingly interested in Doctor Newell's paper, particularly the last one. About 50 years or more ago, Doctor Jacobs of Brussels, Belgium, visited this country. He saw one of my operations and asked for a case of hysterectomy. I gave him one two days later, and he worked on it for about half an hour and did some French cussing—it was too hard and I had no business to give him a case of that kind. So I told Doctor Henrotin to tell him that was the easy sort of case which I usually turned over to my assistants.

The woman developed a ureteral fistula on the right side, which I noted. I took out the uterus first, about two weeks later, and then opened the abdomen. I believe there was nothing done in the way of implantation up to that time, in this country anyway. I put a catheter into the bladder to see which would be the best place and the most normal position to implant it, opened the bladder and implanted the ureter into the bladder, pulled the ureter up a short distance and fastened the catheter to the vulva. Three days later, I took it out and the woman was all right. I followed the case for about a year and she continued to be normal.

The next case was similar, on the opposite side, and I did not bother about a catheter. So far as I know, there had been no ureteral implantations up to that time. I think four or six weeks later, in some German gynecologic journal, Professor Stoeckel of Kiel, now at the University of Berlin, described a case upon which he operated a few days before or a few days after mine. I reported my case to the New York Obstetrical Society.

DR. CURTIS TYRONE (New Orleans, La.): With regard to injury to the ureters, one reason why we are in favor of vaginal hysterectomy is because there is less damage to the ureters. In the two deaths of the 311 cases we have had, there was no evidence of injury to the ureters.

DR. PARKE SMITH (Cincinnati, Ohio): I should like to report a case of ureteral injury, the successful repair of which is an example of a method that, unfortunately, has received little attention in the literature.

The injury was recognized at the time of operation and an end-to-end anastomosis was performed. Following recovery, ureteral dilatation was carried out for about two months or until the patient, unfortunately, fractured her right hip.

She was not seen by a urologist for about a year and a half, at which time she was complaining of some discomfort in the region of the right kidney, the ureter of which had suffered the damage referred to above. At that time, the urologist was unable to pass any type of ureteral instrument beyond the point of anastomosis and I was asked to see her in consultation.

Intravenous pyelography showed the kidneys to have equal function, with only a moderate amount of dilatation of the ureter or renal pelvis beyond the stricture on the right side. As this kidney was evidently in excellent condition and worthy of salvage, it was appreciated that it would be necessary to provide it with a new drainage system.

Because of the massive scar tissue at the site of the previous operation and the shortness of the ureter, it was deemed impractical to undertake another end-to-end anastomosis or to implant the ureters into either the bladder or rectum. We felt that the least hazardous, and probably the method which would assure the greatest likelihood of success, would be to make a lateral anastomosis between the right and left ureter, according to a procedure first reported by Dr. William Lower.

Prior to operation, two catheters are passed into the good ureter. A transperitoneal approach is made; the strictured ureter is ligated at the point of the stricture, liberated and brought to the side of the good ureter, retroperitoneally. The opening of the anastomosis is usually about 2 cm. in length. The cut edges of the incision are brought together with No. 0 plain catgut. The area of anastomosis is anchored to the underlying fascia with No. 2 chromic catgut ligatures. One of the two catheters in the good ureters is passed into the transplanted ureter just prior to the completion of the anastomosis. The area is drained through a stab incision in the flank and the peritoneum is closed tightly, without drainage.

There was very little drainage through the flank incision. The patient has been seen repeatedly since operation. Both intravenous and retrograde pyelograms demonstrate the efficiency and patency of the point of an anastomosis at this time, 11 months after operation.

Dr. Guy L. Hunner (Baltimore, Md.): Regarding Doctor Newell's interesting paper, I shared with him in the early days great pessimism over the results of ureterovesical implantation. In those days, we usually performed direct implantation and, as he says, with resultant scar at the site of the implant and consequent ectasia of the tract above and destruction of renal function. In more recent years, I have performed ureterovesical implantation with a fair degree of confidence justified by the end-results. Advantage is taken of the Coffey principle of indirect implant to favor valve formation. The anastomosis is made as near the base of the bladder as conveniently possible, to obviate wide excursions and possible kinking of the ureteral lumen when the bladder fills and empties. A large open-tip indwelling ureteral catheter helps one adjust the oblique trough of bladder wall about the ureter, prevents too great compression of the ureteral lumen during the anastomosis, and prevents too much tension being applied to the fixation ties. Probably, most important of all, the indwelling catheter splints the tissues about the anastomosis in proper alignment, and insures perfect renal drainage until healing is well advanced, the edema of operation trauma has subsided, and the ureteral and bladder mucosae have joined. During the 10 to 14 days the indwelling catheter is in place, the renal pelvis may be irrigated twice a day with a solution of 1 to 5000 silver nitrate, and once a day an instillation of 1 to 1000 silver nitrate is left in the bladder to prevent, or hold in check, any cystitis which is so liable to develop from the presence of a long indwelling ureteral catheter.

Dr. Quitman U. Newell (St. Louis, Mo., in closing): I am sorry that the surgeons did not have more to say about this important subject. Some time ago when I reported our first series of ureteral injuries, one physician said that he would not have a man on his staff if he cut or injured a ureter while performing a pelvic operation. I have cut one and tied it, and I did not know I had injured the ureter until the patient died, and at autopsy it was discovered that one ureter had been ligated. I do not know of any way to prevent this accident if you do much surgery. It is a common accident and at times is, apparently, unavoidable.

The case of Doctor Smith's is very interesting. A case similar to the one Doctor Hunner mentioned was operated upon by me just three weeks ago. I transplanted the ureter into the bladder and used a ureteral catheter as a splint to keep the ureter in place. The result was wonderful.

I feel that end-to-end anastomosis of cut ureters is a safe and sound procedure and should be performed where possible, and thus preserve good kidney tissue and not remove the kidney.

FEMORAL HERNIA

REPORT OF NINETY OPERATIONS

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FEMORAL hernia, compared with inguinal hernia, is rare. Some idea of the relative frequency is obtained by referring to our records of the Henry Ford Hospital. During the 20-year period, 1916 to 1936, there were 241,037 admissions to the Henry Ford Hospital, and of this number, we have performed 4,530 operations for inguinal hernia and 90 operations for femoral hernia, giving a ratio of approximately 50 to 1, and an average of three femoral herniae a year.

A study of these 90 operative cases of femoral hernia, 88 primary and two recurrent, was undertaken for the purpose of estimating the end-results and comparing the operative procedures employed at this hospital. The literature on femoral hernia is replete with descriptions of variations in operative technic, but is deficient in records of the end-results. This shortcoming is not surprising when it is pointed out that, with but few exceptions, the total number of femoral herniae coming under the observation of any one surgeon is relatively small.

Sex Incidence.—The usual statement that femoral hernia is more common in women than in men is not borne out in this series, for, as shown in Table I, the males outnumber the females by 50 per cent. This difference may be due to the fact that the bulk of our hernia practice is industrial in character, and, as such, contains a greater proportion of males than exists in groups of patients drawn from the nonindustrial elements of the population.

TABLE I

SEX INCIDENCE

	No. of Patients	Percentage
Male	54	60.0
Female	36	40.0
Totals	90	100.0

Age Incidence.—The age incidence of the patients is shown in Table II. The youngest patient was a nine-year-old girl, with a small femoral hernia, and the oldest was a 92-year-old woman, with a strangulated femoral hernia. The greatest number of patients, 76.7 per cent, were in the fourth, fifth and sixth decades, *i.e.*, between the ages of 30 and 60. This is a period of greatest physical activity, but at a time of life when degenerative processes are be-

ginning to exhibit themselves. In a recent review of inguinal herniae,[5] it was shown that 80 per cent of inguinal herniae appeared in the third, fourth and fifth decades, *i.e.*, between the ages of 20 and 50. The appearance of femoral hernia at one decade later than inguinal hernia suggests that muscular weakness is an important factor in the etiology of femoral hernia.

TABLE II

AGE INCIDENCE

Age Group	Decade	No. of Patients	Percentage
0–9	1	1	1.1
10–19	2	3	3.3
20–29	3	6	6.7
30–39	4	25	27.8
40–49	5	29	32.2
50–59	6	15	16.7
60–69	7	8	8.9
70–79	8	2	2.2
80–89	9	0	0.0
90–100	10	1	1.1
Totals		90	100.0

Truss.—Only nine patients, or 10 per cent of the total, had worn a truss previous to operation.

Trauma.—Twenty-two patients, or 24.4 per cent of the series, gave a definite history of trauma in connection with the appearance of their hernia. This figure is low in comparison with that of 62.1 per cent obtained in our series of inguinal herniae.

Obesity.—Increased preperitoneal fat does not appear to be a factor in the production of femoral hernia since, as shown in Table III, two-thirds of the patients in the series weighed less than 150 pounds, and one-third less than 125 pounds.

TABLE III

WEIGHT OF THE PATIENTS

Weight	No. of Patients	Percentage
100–124	29	32.2
125–149	30	33.3
150–174	27	30.0
175–200	4	4.5
Totals	90	100.0

Incidence of Pregnancies.—There were 36 females in the series, of whom 22, or 61.1 per cent, had one or more full term pregnancies and 14, or 38.9 per cent, had not been pregnant. The findings in Table IV are, therefore, inconclusive regarding the influence of child-bearing on the etiology of femoral hernia.

Associated Inguinal Hernia.—There were 21 patients in this series representing 22.3 per cent of the total who had been operated upon previously for

inguinal hernia on the same side as the femoral hernia appeared. Some of these patients, no doubt, were subjected to two operations because of a diagnostic error, but this finding suggests that a more than casual relationship exists between femoral and inguinal herniae and tends to support the congenital or preformed saccular theory of femoral hernia. This observation also directs attention to the advisability of examining the femoral canal during all operations for inguinal hernia.

TABLE IV

INCIDENCE OF PREGNANCIES

No. of Pregnancies	No. of Patients	Percentage
0	14	38.9
1	6	16.7
2	10	27.8
3	2	5.5
4	3	8.3
5	0	0.0
6	1	2.8
Total females	36	100.0

Duration of Hernia before Operation.—Table V indicates the present-day trend toward early operation, for here it is shown that 57.8 per cent of the patients were operated upon within one year of the appearance of their femoral herniae.

TABLE V

DURATION OF HERNIA BEFORE OPERATION

Time	No. of Patients	Percentage
Up to one month	24	26.7
1 to 6 mos.	15	16.7
6 mos. to 1 yr.	13	14.4
1 to 2 yrs.	13	14.4
2 to 5 yrs.	15	16.7
5 yrs. plus	10	11.1
Totals	90	100.0

Side Involved.—Just as in inguinal hernia, we find that femoral hernia is more common on the right than on the left side, but the difference is more pronounced in femoral than in inguinal herniae. The ratio between right side and left side in our series of cases is 70 to 30 in femoral hernia and 55 to 45 in inguinal hernia. A satisfactory explanation for this predilection is wanting.

Incarceration and Strangulation.—A total of 21 patients, or 23.3 per cent of the series, was admitted for emergency operations because of incarceration, while only 1.4 per cent of our inguinal herniae were incarcerated. This comparison points out the greater potential danger of untreated femoral herniae, the seriousness of which is emphasized by the observation that in

eight cases, or 36.4 per cent of the incarcerations, there was interference with the blood supply of the intestine. This strangulation necessitated resection in three patients, two of whom died. One other patient who was operated upon for strangulation died of shock, making a total of three deaths out of 21 incarcerated cases, giving a mortality rate for the group of 15.2 per cent. It is recognized that the sac wall alone may strangulate and become gangrenous, but this condition was not observed in any of the cases in our series.

TABLE VI

SIDE INVOLVED

Side Involved	No. of Patients	Percentage
Right	63	70.0
Left	27	30.0
Totals	90	100.0

Diagnosis.—A correct diagnosis of femoral hernia was made in 74 out of 90 patients, a percentage of 82.2. The principal error was in mistaking a femoral for an inguinal hernia. In males, there should be no great difficulty, except in dealing with recurrent inguinal hernia, where the protrusion of the sac does not always appear at the external inguinal ring. In obese females, the excess subcutaneous fat not uncommonly renders identification of anatomic landmarks extremely difficult, so that it may be impossible to determine whether the hernial sac appears internal and above the pubic spine, as in inguinal hernia, or external and below the pubic spine, as in femoral hernia. The observation has been made that in cases of doubt the hernia usually turns out to be femoral. The failure to distinguish between inguinal and femoral herniae is not of serious import in any instance, and is of no consequence if the inguinal approach to femoral hernia is practiced.

Anesthetics.—Table VII illustrates the growing popularity of spinal anesthesias in this hospital. However, we feel that local anesthesia is the choice for the poor-risk patient.

TABLE VII

ANESTHETICS EMPLOYED

Type	No. of Patients	Percentage
Spinal	31	34.4
Ethylene and ether	28	31.1
Ethylene	15	16.7
Local	7	7.8
Avertin and ethylene	5	5.6
Ether	2	2.2
Nitrous oxide and ether	2	2.2
Totals	90	100.0

Method of Repair.—The classic operation of Bassini for femoral hernia was performed in 60 per cent of the patients, with a recurrence rate of

9.7 per cent. The high or inguinal route for both treatment of the sac and repair of the canal was adopted in 30 per cent of the patients, with a rate of recurrence of 7.4 per cent. The combined method of inguinal treatment of the sac and the femoral or low approach for the repair of the canal was employed in 10 per cent of the patients, with no recurrences. The use of the combined method arose in most instances from diagnostic error where a femoral hernia was diagnosed as inguinal hernia, preoperatively. The inference drawn from the foregoing figures is that the inguinal route gives better results than the femoral, but if we include the combined repair with the femoral group, the recurrent rate would then be 7 per cent, giving a slight advantage in favor of the femoral approach.

TABLE VIII

METHOD OF REPAIR

Approach	No. of Patients	Percentage	No. of Recurrences	Percentage
Femoral	54	60.0	5	9.7
Inguinal	27	30.0	2	7.4
Combined	9	10.0	0	0.0
Totals	90	100.0	7	

The inguinal operation employed was that of Lotheissen,[8] *i.e.*, suturing the conjoined tendon to Cooper's ligament, in an endeavor to close the superior orifice of the femoral canal. The conception of this operation is anatomically sound, and whether the conjoined tendon, the mobilized rectus sheath, the external oblique aponeurosis, or the transversalis fascia[3] is sutured to Cooper's ligament, a firm barrier is placed over the femoral opening at the conclusion of the operation. The ultimate success of the operation depends, however, on sound healing of the opposed structures. The failure of the conjoined tendon to unite with Cooper's ligament is witnessed by the number of operative failures and the many modifications suggested. The lack of success is due, in part, to the placing of the structures out of their normal course of alignment and in part to the necessity for suturing under tension.

The Moschcowitz operation[10] consists of an attempt to approximate two relatively unyielding structures, Poupart's and Cooper's ligaments. A firm fibrous union between these structures can be obtained only when Poupart's ligament is lax enough to permit apposition to Cooper's ligament, without tension. This prerequisite limits the application of this type of repair. The Roux operation achieves the same result by inserting a metal staple through Poupart's ligament and driving it home into the superior ramus of the pubic bone.

The problem of closing the entrance to the femoral canal appears to be best solved by the use of fascial strips as advocated by Auchincloss,[1] Carscadden[2] and Payne.[11] Strips of fascia obtained from the fascia lata or from the aponeurosis of the external oblique muscle are threaded through Poupart's and Cooper's ligaments from Gimbernat's ligament outward to the femoral vessels, thereby forming an effective barrier against peritoneal protrusions.

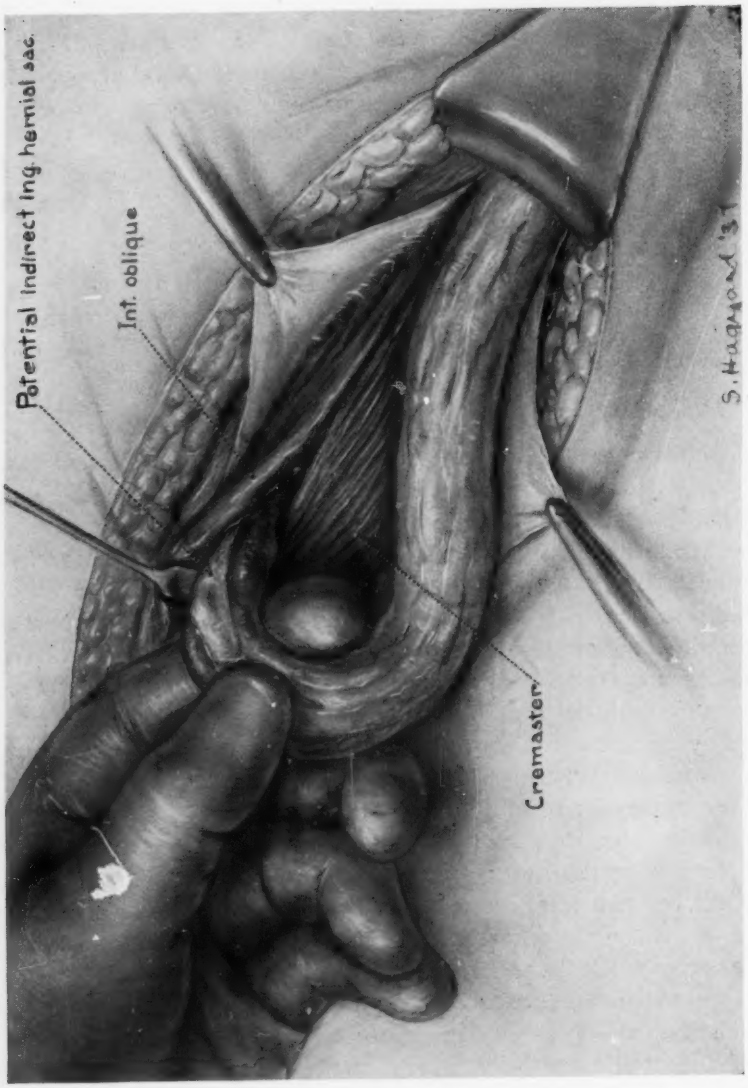

FIG. 1.—The spermatic cord has been dislocated from its bed. Retraction of the internal oblique and transversalis muscles at the internal inguinal ring plus traction on the cord has displayed the potential, indirect inguinal hernial sac.

We did not make use of this method in any of the cases in this series, but in consequence of dissatisfaction with our results, we are now utilizing this type of repair in large femoral herniae with the hope of reducing our recurrent rate of 7.4 per cent.

The femoral approach provides ready access to the sac of a femoral hernia, and the classical Bassini operation is much easier to perform than the inguinal operation. Satisfactory results follow the application of the Bassini repair in small femoral herniae when the sac contains only peritoneal fluid or at most a tag of omentum. However, when the femoral hernial sac is large and contains omentum or intestine, better results will follow the use of the inguinal operation.[12] The weakness of the femoral operation lies in the closure of the lower instead of the upper end of the femoral canal. The inguinal operation, while, admittedly, more difficult to perform, is actually a safer procedure than the femoral operation, because the chance of wounding an aberrant obturator artery or the bladder is reduced to a minimum. All incarcerated femoral herniae should be dealt with by the inguinal approach so that adequate inspection of the imprisoned intestine may be made. It is possible, when manipulating the sac below Poupart's ligament, for an unobserved loop of intestine with a damaged blood supply to slip back into the abdominal cavity and to be followed by perforation and a fatal peritonitis. Furthermore, if intestinal resection is indicated, the involved segment of bowel can be resected and an anastomosis made without the necessity of either making a second incision or sectioning Poupart's ligament.

It is desired to call attention here to a modification of the usual method of entering the peritoneal cavity when performing the inguinal operation for femoral hernia. One of the arguments brought forth against the inguinal approach is the difficulty of isolating the hernial sac. The method about to be described simplifies the procedure and eliminates the tedious dissection necessary to separate the transversalis fascia from Poupart's ligament and to identify the fat-covered neck of the sac. Also, the possibility of wounding the femoral vein is practically excluded. The modification suggested is an adaptation to femoral hernia of Hoguet's[6] method of dealing with a direct hernial sac. It is employed in the following manner:

After the aponeurosis of the external oblique muscle is opened in the line of the inguinal canal, the cord or round ligament, as the case may be, is dissected from its bed. Gentle traction applied to the cord, plus upward and outward retraction of the internal oblique and transversalis muscles to expose the internal ring, will display the constant, potential indirect inguinal hernial sac. It may be recognized readily on the postero-internal aspect of the cord by its crescentic border (Fig. 1). This potential indirect hernial sac is picked up, separated from the other structures of the cord and opened to permit the examining index finger of the surgeon to enter the peritoneal cavity and verify the diagnosis of femoral hernia (Fig. 2). The medial margin of the opened peritoneum is now grasped with artery forceps, and by means of traction, it will be found possible to deliver the entire femoral hernial sac into the wound

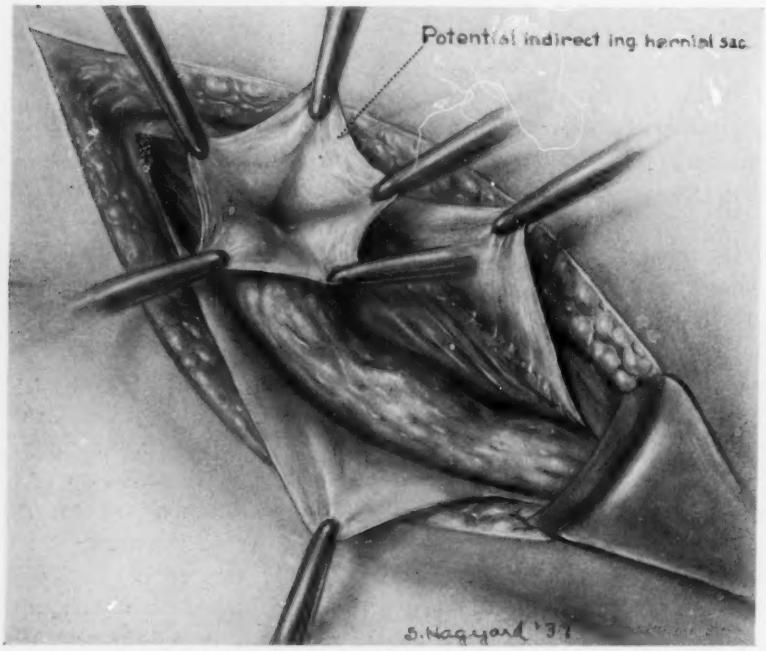

FIG. 2.—The potential indirect inguinal hernial sac has been separated from the structure of the spermatic cord and opened.

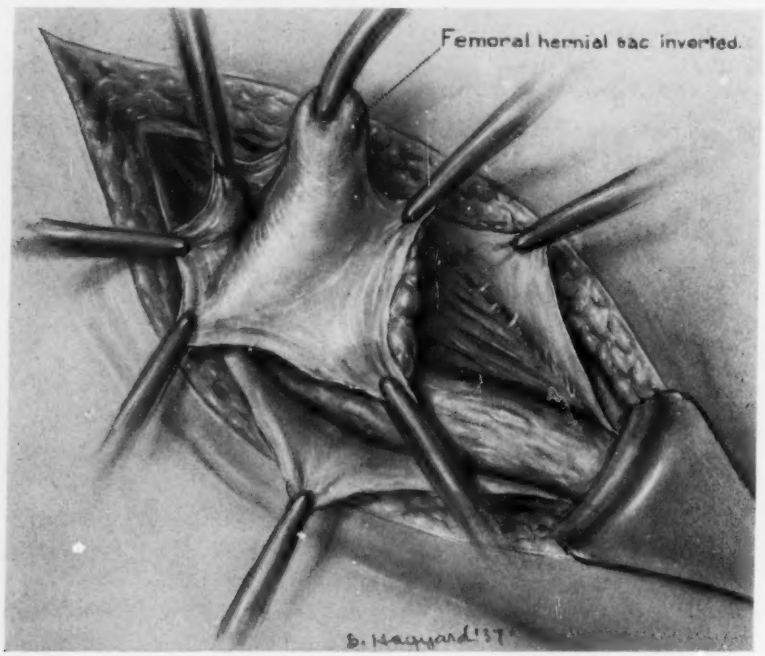

FIG. 3.—Traction on the medial margin of the sac has resulted in pulling up the slack peritoneum and with it the femoral hernial sac which has been inverted.

(Fig. 3). Even large sacs, after reduction of their contents, can be brought up through the femoral canal with ease. In some instances adhesions of the sac to the structures in Scarpa's triangle, or edema of the preperitoneal fat surrounding the sac, will prevent its passage through the femoral canal. In these cases the temptation to section the neck of the sac above Poupart's ligament and leave the body of the sac in situ below must be resisted because, though the hernia is cured, the bulk alone of the remaining sac, even if it does

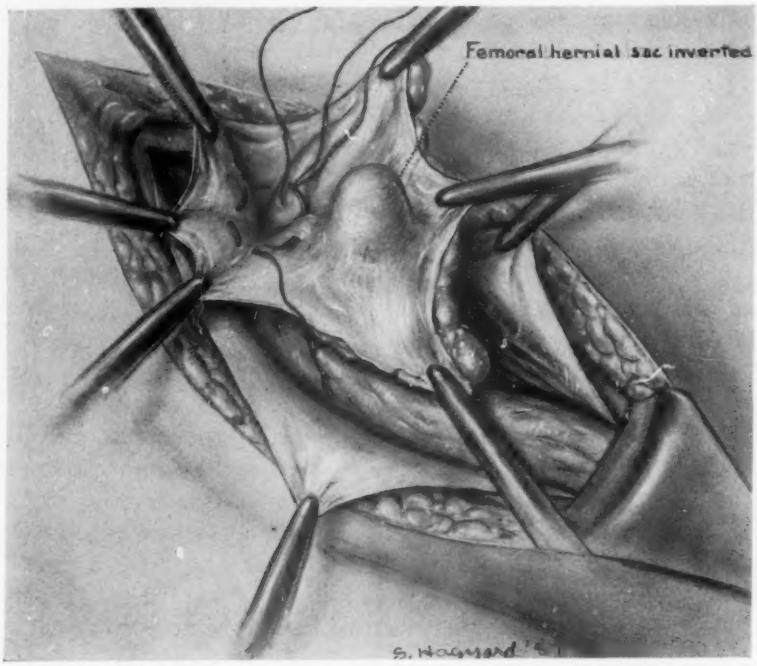

FIG. 4.—A purse-string suture of silk is closing the peritoneum proximal to the neck of the femoral hernial sac. The latter will be cut away with the remaining redundant peritoneum.

not fill with fluid, will suggest to the patient that the hernia is still present. The procedure recommended in these cases is to retract the lower skin flap and remove the sac below Poupart's ligament and, when this is done, the neck of the sac can be pulled through the femoral canal and delivered into the wound above Poupart's ligament. Closure of the peritoneum is effected by a purse string or continuous suture inserted proximal to the mouth of the femoral hernial sac (Fig. 4). After the excess peritoneum, including the femoral hernial sac, is trimmed away, the neck of the sac retracts back through the internal inguinal ring. It is now necessary to incise the fascia transversalis in the floor of Hesselbach's triangle in order to expose the superior opening of the femoral canal. In many instances, and in all obese patients, the canal will be found partially occupied by preperitoneal fat which surrounds the sac in addition to its usual fatty envelope. When this fatty tissue is pulled up through the femoral canal, the superior opening is perfectly displayed, Cooper's liga-

ment posteriorly, Poupart's ligament anteriorly, Gimbernat's ligament medially, and the femoral vein laterally. The operator now proceeds to close the femoral canal, using his favorite method. When this is accomplished, the incision in the transversalis fascia must be repaired in order to effectively close the floor of Hesselbach's triangle and prevent the formation of a direct inguinal hernia. The operation is completed by uniting the conjoined tendon and internal oblique to Poupart's ligament behind the cord, and then closing the external oblique aponeurosis over it. This approach has its special adaptation in dealing with strangulated and incarcerated femoral herniae, for, by this method, the peritoneal cavity is entered above the constricting ring. Furthermore, by pulling up the slack peritoneum a sufficiently large opening can be made to allow adequate inspection of the incarcerated intestine without weakening the abdominal wall or endangering surrounding structures.

In presenting this method of entering the peritoneal cavity above the neck of the sac, no claim for originality is made. It has undoubtedly been employed by others, but we have been unable to find any reference to it in the literature. Its use in 20 cases by one of us (L. F.) has confirmed our impression of its advantage over the usual method of approach to the sac of a femoral hernia when performing the inguinal operation.

Unusual Contents of the Sac.—In three cases of this series, the femoral hernial sac contained a viscus other than the omentum and intestine. In one case a fallopian tube was adherent to the sac and in two instances the sac contained the appendix. Watson,[13] up to 1923, collected from the literature 181 cases of an appendix in a femoral hernial sac, of which only four were in males. Since 1923, we have obtained 11 additional case reports from the American and British literature, only one of which occurred in a male.[4] Thus, of a total of 192 cases of appendicitis in a femoral hernial sac only five were in males. The extreme rarity of the condition in the male prompts us to add the following case report:

Case Report.—H. F., age 68, was admitted as an emergency to the Henry Ford Hospital, November 26, 1932. He gave a history of having been first aware of distress in the right lower quadrant of the abdomen seven days previously. At the same time, he had noticed a lump in his right groin which had increased in size after the application of a hot water bottle. He had been nauseated only once and that at the onset of the pain. He had not been confined to bed, although his activities had been restricted and he had experienced some pain on walking. Early on the day of admission, he was seen on the outside by one of us (R. D. M.) and a diagnosis of incarcerated femoral hernia was made, but, because there was so little systemic reaction, operation was not pressed. The swelling in the groin, which measured 4.5x3.5 cm. in size, was tender on examination. W.B.C. 9,400, polymorphonuclears 60 per cent. Later in the day operation was advised, and was performed early in the evening. The patient was otherwise in excellent health and fine physical condition.

Operation.—November 26, 1932: Under avertin-ethylene anesthesia, an incision, parallel to Poupart's ligament, disclosed a thickened, discolored, femoral hernial sac. On opening the sac, its only content was a tightly packed in, adherent, gangrenous appendix. Fortunately, the mobility of the cecum permitted a routine removal of the appendix with purse-string inversion of its base, but in order to deliver the cecum into the wound,

Poupart's ligament had to be partially incised. A high ligation of the sac with a purse-string suture of silk and closure of the femoral opening by uniting the remnants of Poupart's ligament to the pectineal fascia and muscle completed the essential steps of the operation. This patient would not remain in bed—walking into the bathroom each day, including the first postoperative day. Convalescence was uneventful. It is now six years since the operation and there has been no recurrence of the hernia in spite of the fact that Poupart's ligament was partially severed.

Treatment of the Hernial Sac.—The method of dealing with the hernial sac is outlined in Table IX. The favorite method of closing the sac was by purse-string suture, which was done in 52.2 per cent of the cases. Twisting the neck of the sac before transfixion was done in 24.5 per cent, and transfixion alone in 23.3 per cent of the cases. The method of closing the sac in this series had apparently very little bearing on the success of the operation, for, of the seven recurrences, four followed purse-string sutures, two transfixion alone and one twisting. The better showing following twisting of the sac must be discounted because this maneuver was carried out only when the hernial sac was small. The neck of the sac, after closure, was transplanted and fixed to the anterior abdominal wall in 16.7 per cent of the cases, and was followed by recurrence in two instances.

TABLE IX

TREATMENT OF THE HERNIAL SAC

Closure	No. of Patients	Percentage
Purse-string	47	52.2
Twisting	22	24.5
Transfixion	21	23.3
Totals	90	100.0
Transplanted	15	16.7

Suture Material.—As indicated in Table X, we used silk in all femoral herniae repairs unless there was a definite contraindication to its use. Thus we find that in 72.8 per cent of the operations the suture material used was silk. Catgut was used in most strangulated cases when the possibility of resection was present and when the condition of the skin was such that healing might be impaired. There were six recurrences among the 65 cases repaired with silk, a percentage of 9.2, and only one recurred among the 25 cases repaired with catgut, a percentage recurrence of four. No inference regarding the relative values of the suture materials can be drawn from these figures because the series is too small and because the other factors determining recurrence should be taken into consideration.

TABLE X

Type	No. of Patients	Percentage
Silk	65	72.2
Catgut	25	27.8
Fascia	0	0.0
Totals	90	100.0

Complications of Operation.—Complications following operation for femoral hernia, as shown in Table XI, developed in four patients, a percentage of 4.4. This compares favorably with the 5 per cent figure obtained in our series of inguinal herniae. The complications arising were: Phlebitis, two; pulmonary, one; and wound infection, one. All the patients recovered.

TABLE XI

COMPLICATIONS OF THE OPERATION

Complication	No. of Patients	Percentage
Phlebitis	2	
Pulmonary complications	1	
Wound infection	1	
Total	4	4.4
Operative mortality	4	4.4

The mortality rate of 4.4 per cent, following operation for femoral herniae was much higher than that of 0.24 per cent following operation for inguinal herniae. Of the four deaths in the series, two followed intestinal resection in strangulated cases, in patients being aged 90 and 72, respectively; and two followed additional operative procedures. We strongly deprecate the practice of performing multiple operations. All our case reviews indicate that both mortality and morbidity are increased when the patient is subjected to more than one operative procedure at one time.

Follow-Up.—The results of our efforts to trace the patients upon whom we have operated for femoral hernia are outlined in Table XII. We realize that the presentation of a rate of recurrence of 7.8 per cent, in a series of patients, 45.5 per cent of whom were followed for less than six months, is only an estimate of the true figure which must be considerably higher.

TABLE XII

FOLLOW-UP

Time	No. of Patients	Percentage
Under 6 mos.	41	45.5
6 mos. to 1 yr.	13	14.5
1 to 2 yrs.	10	11.1
2 to 3 yrs.	7	7.8
3 to 4 yrs.	1	1.1
4 to 5 yrs.	1	1.1
5 to 6 yrs.	4	4.5
6 to 7 yrs.	0	0.0
7 to 8 yrs.	1	1.1
8 to 9 yrs.	0	0.0
9 to 10 yrs.	1	1.1
Recurrence	7	7.8
Mortality	4	4.4
Totals	90	100.0

SUMMARY

(1) Ninety operations for femoral herniae are reviewed, with a known rate of recurrence of 7.8 per cent.

(2) The ratio of femoral to inguinal herniae at the Henry Ford Hospital is 1 to 50.

(3) The males outnumbered the females three to two.

(4) A modification of the usual approach to the sac is described.

(5) The relative merits of the femoral and inguinal operations for repair are discussed.

(6) A case report of appendicitis in a femoral hernial sac, in a male, is included.

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DISCUSSION.—DR. R. A. GRISWOLD (Louisville, Ky.): In this very excellent presentation of Doctor McClure's, several important things have been brought out. One was his advice to make a routine exploration of the femoral sac. That was brought to my attention in the case of a female missionary, who came to us, after operation elsewhere, for a right inguinal hernia. I examined the inguinal region and there was slight weakness, but hardly enough to cause the symptoms of which she complained. Because of her insistence, I agreed to reoperate. On getting up at the end of two weeks, however, she said the hernia had returned, and I put her down as a neurotic. Several weeks later, on reexamination, I found a slight impulse over the femoral opening. I operated again and found a small femoral hernia. Since this was repaired, three years ago, she has carried on without symptoms. Since that time, I have routinely tried to put my finger into the femoral canal.

I should like also to emphasize the good points of the inguinal approach, especially when we may have to perform a resection or other procedure on the bowel, for obstruction.

DR. J. W. PRICE, JR. (Louisville, Ky.): Doctor McClure's statistics are very interesting, and the reason I am speaking is because I think his statistics and mine bear some relation. He reported 90 cases among 240,000 admissions. I wish to report three in about one-twentieth that number of admissions. The first femoral hernia I had to operate upon occurred in a patient who was prepared for operation for a fibroid of the uterus, and we found a femoral hernia and promptly dealt with it through the midline incision which we had made. The second patient, age 78, had an incarcerated femoral hernia. We split Poupart's ligament and made a longitudinal incision; the patient made a complete recovery. I should never hesitate to divide Poupart's ligament. Our third patient, age 73, we operated upon under local anesthesia also. It was not necessary to divide Poupart's ligament, but we dealt with the hernia from above. These two elderly patients were not very active anyhow, but they are, so far as I know, getting along well with no recurrence.

DR. HAROLD H. RUTLEDGE (Richmond, Ky.): Because Doctor Coley, who was planning to discuss this paper, had to return to New York, as his substitute I should like to report on 314 consecutive operations for femoral herniae performed at the Hospital for Ruptured and Crippled, during the period from 1925 to 1936. During the past three years the silk technic has been used in all these operations. In 30 consecutive cases there were no deaths, and only one infection; there were two recurrences. This group should be compared with another of 260 cases in which catgut was used. In 60 followed cases in this second group, there were three deaths and seven, or 2.7 per cent, infections; furthermore, there were four recurrences.

Fascial sutures were used freely in the period from 1925 to 1935, especially for large femoral herniae and for recurrent herniae. In 24 such cases in our series, there were two deaths and four infections.

So far as the approach is concerned, we prefer the low for all small primary herniae with narrow femoral canals, and the high or inguinal approach for all recurrent or epigastric or incarcerated herniae or where the orifice is wide. Under these latter conditions, the advantages of approximating Poupart's ligament to Cowper's ligament, and obliterating the opening high up, seem self evident.

DR. ROY D. McCLURE (Detroit, Mich., in closing): I would say that the recurrence rate of 7.4 per cent is simply due to the fact that our follow-up has been poor. This, in turn, is due to the fact that our series of cases represents our entire work during the past 23 years with this type of hernia, and it is difficult to recall one after two decades. It is remarkable, however, when one really gets interested in a subject, how the follow-up improves. The most recent patients of this series have been followed for only six months. Doctor Fallis and I feel that our rate of recurrence would be more likely around 11 per cent, as others have reported, had our follow-up been perfect.

I would refer those of you who are interested in the subject of appendicitis in a hernial sac to an excellent article by C. P. G. Wakeley, Lancet, **2**, 1282–1284, December 3, 1938.

THE THEORY AND PRACTICAL USE OF THE Z-INCISION FOR THE RELIEF OF SCAR CONTRACTURES

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AND

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THE purpose of this communication is to again call attention to a maneuver which for many years has been most useful to us when dealing with contracted scars, particularly those with bridles or webs. The procedure has been so satisfactory in our hands that it seems worth while to comment again on our experiences and to go more thoroughly into the mechanics of the method.

In a paper[1] read before the American Surgical Association in 1931, attention was called to a method of relaxing scar contractures by means of the Z-incision with the transposition of triangular flaps of scar tissue or of tissue considerably infiltrated with scar. This was not a new procedure, for, as far as could be ascertained, the method was first used by Denonvilliers,[2] in 1856, for the relief of an ectropion of the outer third of a lower eyelid. It is interesting to note that although the Z-incision with the transposition of the flaps thus made was used over 80 years ago, and possibly even before that time, the method has, during this period, been rediscovered and described as a new procedure by a number of surgeons.

The literature on the subject, up to 1931, can be found in the paper referred to above.[1] In the last few years, the Z-incision has been illustrated in many of the surgical text-books, and other articles have also been written upon the subject. A. A. Limberg,[3] of Leningrad, has discussed the theory and practice of the procedure in several excellent papers. He has demonstrated, in a most interesting way, the mathematical basis of shifting triangular flaps, and has indicated the possibilities and limitations of the method.

The Z-incision is now well known, and the method is frequently utilized by surgeons who are accustomed to dealing with scar contractures. However, there is still considerable confusion as to the actual technic of Z-shaped relaxation incisions and of the utilization of scar flaps thus formed to relieve scar contraction. Furthermore, we find that there are many who do not understand the principle of the procedure at all, or realize its usefulness.

During the years, we learned by experience the most satisfactory method of making the Z and of forming the triangular flaps. However, after studying the figures shown by Limberg, we have approached the method from the mathematical viewpoint for purposes of accuracy. In checking back over our cases, we have come to the conclusion that simply by trial and error our angles, *etc.*, have been much the same as if we had purposely laid them down in definite degrees.

In Limberg's paper a number of figures are used to demonstrate the theoretical values and limitations of triangular flap shifting. It is important to understand, however, that instead of being able to select any angle desired, in making the Z, transposing the triangular flaps and closing the wound, there are practical limitations which preclude the use of a wide range of angles. In other words, that many of his diagrams are entirely theoretical

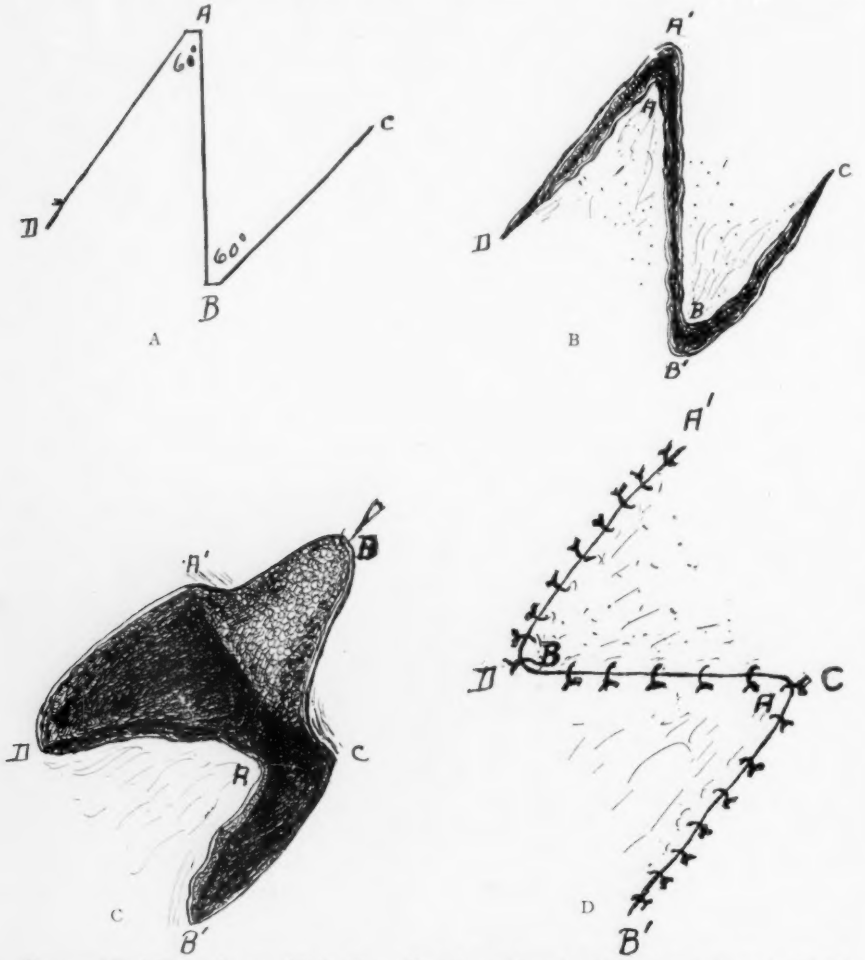

FIG. 1.—(A) A Z was drawn with the three sides of equal length (2 inches) and the angles of 60°. (B) An incision was made along these lines. (C) The flaps were then thoroughly undercut. (D) The flaps were then transposed, and sutured into their new positions. The triangular flaps DAB and ABC are transposed so that the tip A is sutured to point C, and the tip B is sutured to point D.

in character and are not intended to be a guide for actual application in making incisions and transposing tissue flaps.

The mathematical diagrams used in the illustrations are based on Limberg's figures. For purposes of simplicity, we have drawn figures with the sides of the Zs of equal length (two inches). The legends will explain the phases of the theory of the transposition of triangular flaps. A Z-shaped

figure is drawn with the central and arm lines of equal length. The arm lines are laid down from either end of the central line on opposite sides and are parallel to each other. If the figure is completed by drawing lines across the bases of the two triangles outlined by the Z, a parallelogram is formed. The principle upon which the shifting of triangular flaps is based can most readily be understood by considering the two flaps as the triangles which form this parallelogram.

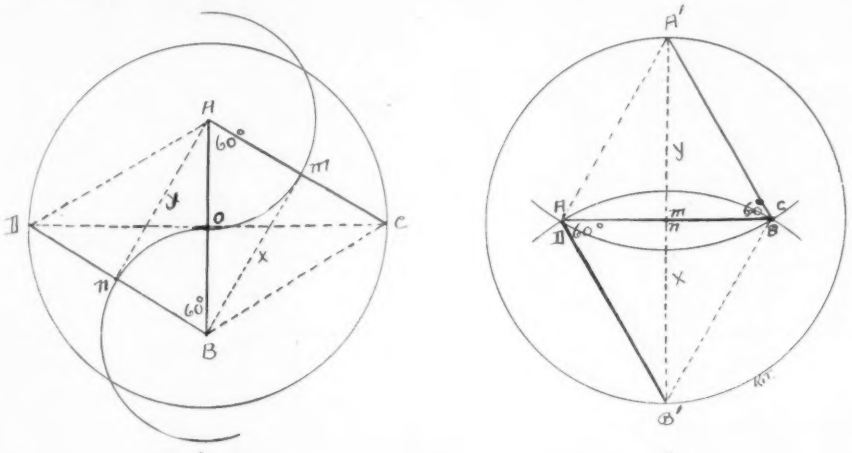

FIG. 2.—(Based on Limberg's diagrams.) Illustrates the geometrical and mathematical transposition of the triangular flaps outlined by the Z.

(1) The line AB, 2 inches long, was drawn, and from the points A and B, the lines AC and BD were drawn on opposite sides, each being 2 inches long and at an angle of 60° to line AB. This formed the Z, DBAC. An incision along these lines forms the two triangles DBA and BAC, the flaps outlined by the Z. Points A and D and points C and B were connected, forming the parallelogram ACBD. The undercutting of the flaps is equivalent to the area of this parallelogram. Connect the points D and C by the line DOC and with O as a center make the circle DC whose radius is DO or OC. The distance between the ends of the line AB or the central line of the Z is the short diagonal, and the distance between the outer ends of the arm lines of the Z (DB and AC) or DOC is the long diagonal of the parallelogram. These diagonals bisect each other so that AO = OB and DO = OC.

When the triangles DBA and BAC are transposed, the line DB must fall on line AC and the line bisecting the angle DAB opposite the line DB will form a straight line with a line bisecting the angle ABC opposite the line AC, since both of these angles are equal. The lines which bisect angles are called medians.

From point A with AO as a radius draw an arc which cuts line AC at M, and with B as a point and OB as a radius draw an arc which cuts line DB at N. Connect points B and M, and A and N. The lines BM or X and AN or Y are the medians of the angles ABC and DAB. X + Y will form a straight line when the triangles DBA and BAC are transposed. OC is the median of ACB and OD the median of ADB. The angles ABC and BCA are equal and the angles ADB and BAD are equal. Therefore the medians are equal. So X = OC and Y = OD and X + Y = OD + OC or DOC, the long diagonal of the parallelogram. So X + Y, or the distance between A and B after transposition, is equal to the distance between D and C, the outer ends of the lateral incisions.

(2) The line A′B′, equal to X + Y, is drawn. From point A′ with AC as a radius the arc CA is drawn. From point B′ with BD as a radius the arc DB is drawn. These arcs cut each other at points AD and CB. The points A′ and CB, and CB and AD, and AD and B′ are connected. The transposition is complete. The circle A′B′ with MN as center and Y or X as a radius was drawn. This circle and that of Diag. 1 are equal since they have the same diameters.

The length of the line A′B′ can be computed from the value of the line X or Y. When the angle is 60°, the value of X is ⅞ of AB and the line A′B′ will be ⅞ + ⅞ or 1¾ of AB. AB is 2 inches long so A′B′ will be 3½ inches. The relaxation gained is the difference between AB and A′B′, or 1½ inches.

The line of incision along the central line of the Z is the short diagonal and an imaginary line joining the outer ends of the arm incisions of the Z is the long diagonal of the parallelogram. The transposition of the triangular flaps interchanges the position of the diagonals. The difference between the lengths of the two diagonals is the amount of relaxation secured.

The important factor in the theoretical and practical application of this

method is the size of the angles which are made by the arm lines in relation to the central line of the Z. The wider these angles are, the greater is the difference between the diagonals and vice versa. Above 130° the difference becomes so great that the triangles cannot be transposed. Below 30° the

FIG. 3

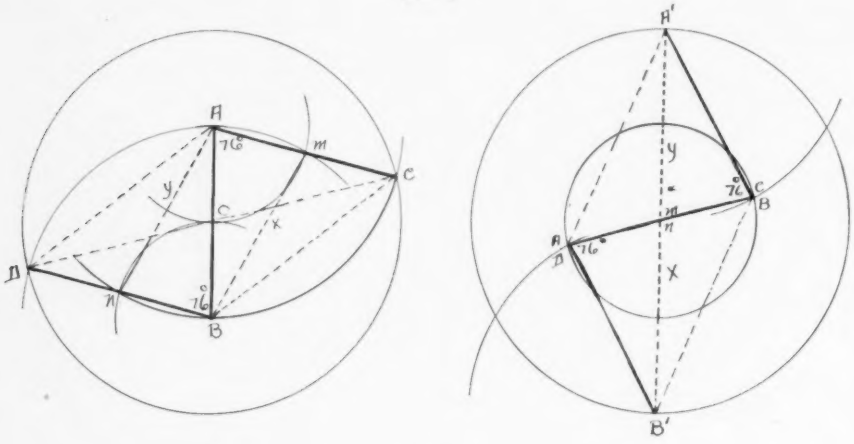

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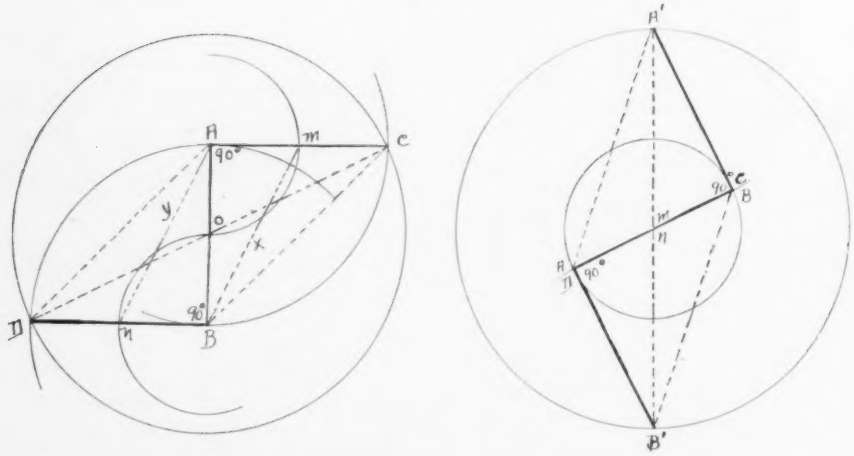
FIG. 4



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FIGS. 3 and 4.—(Redrawn from Limberg's diagrams.) Figure 3 illustrates the transposition of the triangles when the angles are 76° and the sides of the Z equal, 2 inches long.

Figure 4 shows the transposition of the triangles with sides 2 inches long but with angles of 90°. In Figure 3, the relaxation is equal to the length of the midline of the Z, while in Figure 4, the relaxation is 2½ inches. This angle cannot be used practically in the transposition. It immediately becomes evident that the variable factor is the angle at which the lateral incisions of the Z are made. The larger the angle the greater the relaxation, and vice versa. In computing the values of the median at various angles it can be seen that there are limitations to the transposition. When the median becomes so small that the sum of the two medians, or the long diagonal of the parallelogram, is less than the short diagonal, transposition is impossible because the triangles will overlap. It was found that this occurred below the 32° angle. When the long diagonal becomes greater than 2¾ of the short diagonal, transposition becomes impossible because the triangles cannot meet. This occurs above the 130° angle. The *theoretical* transposition, therefore, lies between the 32 and 130° angles.

short diagonal or central line becomes greater than the long diagonal so that transposition is impossible. In actual practice, further factors enter which limit the use of these triangles to angles ranging between 20° and 60°. It is

sufficient to say that the limited elasticity of the scar infiltrated skin, the thickness of the flaps essential to viability, the location on the body, and the theoretical limitations make the 60° angle the one of choice. Should it be desirable to make the angles unequal, then the smaller angle can be cut as low as 20°.

Preliminary Preparation.—As in every other operation which is not in the emergency class, it is important to have the patient in the best possible physical condition, and every effort should be made to this end before beginning operative work.

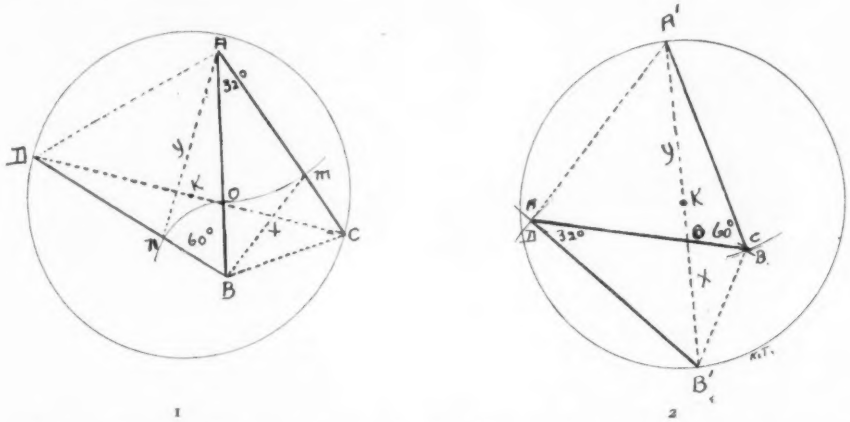

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FIG. 5.—(Based on Limberg's diagrams.) In Z's with unequal angles and equal sides, the transposition is more complex.

(1) The line AB is drawn 2 inches long. The angle BAC of 32° is laid off from the line AB at A and the line AC drawn 2 inches long. From the point B the angle ABD of 60° is laid off and the line BD drawn 2 inches long. We now have the Z, DBAC with equal sides and unequal angles. The points D and A are connected and the points B and C, forming the rhomboid DBCA. The points D and C are connected by the line DOC. The midpoint K is found and a circle drawn enclosing the figure. AB is the short diagonal and DOC the long diagonal of the rhomboid, which cut each other at the point O. From point A with radius of AO an arc was drawn which cuts AC at M. From point B with radius of BO an arc was drawn which cuts BD at N. The line BM = OC and line DO = AN. Therefore X + Y = DOC, or the long diagonal which is the distance between the outer ends of the lateral incisions of the Z, DBAC. The angle AMB = ANB. When the triangles BAC and DBA are transposed, the line AC will fall on DB and the lines X and Y will be a straight line.

(2) With the line A'B', which is equal to X + Y, as a diameter, a circle was drawn with K as a center. With A' as a center and the distance DB as a radius, an arc was drawn which cuts an arc drawn with B' as a center and BC as a radius at point CB. With B' as a center and AB as a radius, an arc was drawn which cut an arc drawn with A' as a center and AD as a radius at point AD. The points A' and CB, and CB and AD, and AD and B' were connected. The triangles have now been transposed and the diagonals have changed places as before.

It is to be noted that the point AD in Diag. 2 is almost on the Circle A'B', while in Diag. 1, D is on the circle of DC. The large triangle, therefore, moves very little laterally. The opposite is true of the small triangle BAC. So angles of unequal size can be used where relaxation is desired but where the lateral slack is unequal on the sides of the Z. This can be used particularly around the eye, nose or mouth. In all cases the sides of the Z should be of equal length to secure the maximum relaxation of any given angle.

Scar contractures, with bridles or webs, usually follow the healing of extensive burns or tissue losses and often develop in spite of careful and up to date methods of treatment. They are most frequently found in the axillae; where the extremities join the trunk; in the neighborhood of joints; on the hands and feet; in the mouth; and on the face and neck.

It is advisable to delay operative work on contracted scars for at least six months after healing has taken place, and often longer, until nature assisted by physical therapy of one sort or another has had time to do all that she can and will. It has been our experience that contracted scars are frequently

operated on entirely too early. A few months will make a vast difference in the condition of a scar and of the tissues around it, and by making haste slowly useless operations can often be avoided, and a better final result obtained if operation is required. When the scar has fully matured and softened, and the circulation is in the best possible condition, we then feel justified in taking steps to properly correct the contraction.

Anesthesia.—If local anesthesia is used, nerve block is to be preferred as it must be borne in mind that infiltration of scar tissue unquestionably lowers its resistance and retards healing, so we feel that the infiltration method is contraindicated in those cases where scar flaps are to be shifted.

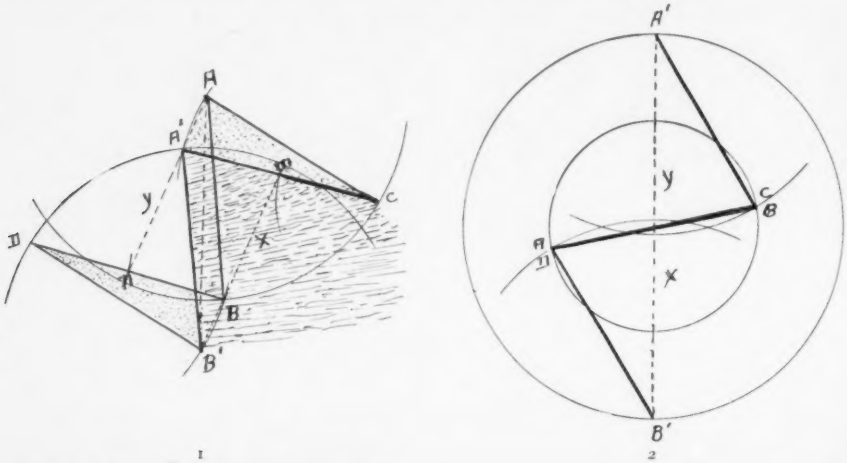

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FIG. 6.—(Based on Limberg's diagrams.)

(1) The practical application of the Z-incision with the transposition of triangular flaps is definitely limited by a number of factors. The flaps are usually cut in scar which has less elasticity than normal skin. They must be cut thick enough to carry sufficient blood supply to assure viability. The contour of the body will produce counter pulls which influence the position of the flaps once they are cut. After the incision is made, these factors cause the flaps to contract so that the angles become larger than originally planned. We have found that this contracture changes the angle about 16°. For example, an angle of 60° will become an angle of 76° after the flaps are cut, and this is demonstrated as follows: DBAC is the Z as planned with sides 2 inches long and angles of 60°. When the flaps are freed, they take the positions of DBA and B'A'C. The incision along AB spreads to AB'. This separation is equivalent to about ¼ of the length of the line AB. This change makes the sum of the medians greater than the long diagonal of the parallelogram.

(2) The sum of X + Y was used as a diameter and the flaps reconstructed geometrically. It was found that the advantage gained was equal to that of 76°. Practically, therefore, the actual lengthening to be expected can be calculated for an angle 16° larger than the one used. If a 60° angle is used, the relaxation can be calculated roughly as equal to the length of the midline of the Z instead of ¾ of the line. Practical application has definitely shown that flaps with angles larger than 60° cannot be transposed and sutured. If the outline of the Z is made with 76° angles, the flaps will have about 92° angles after cutting. It is not possible to transpose and suture flaps with almost right angles. The lower limit of practical application is below the theoretical limit for the same reasons, and one can transpose and suture flaps with angles of 20°. The difficulty here lies in making the flaps too narrow to carry a blood supply. Practically, therefore, the limits of use lie between the 20° and 60° angles.

Our preference in all suitable cases is for general anesthesia, usually induced by avertin, from 60 to 75 Mg. per kilo, which is given in the ward, and is supplemented in the operating room by nitrous oxide and oxygen. This eliminates preoperative terror which so often leaves a serious lasting impression, especially with children, and does away with the memory of preliminary preparations for the adult.

Preparation for Operation.—Prepare the area for operation by any method in which you have confidence, being sure that the materials used will not

cause subsequent blistering of the scar. In our own work, after ether and alcohol are used, we paint the field several times with a solution of potassium

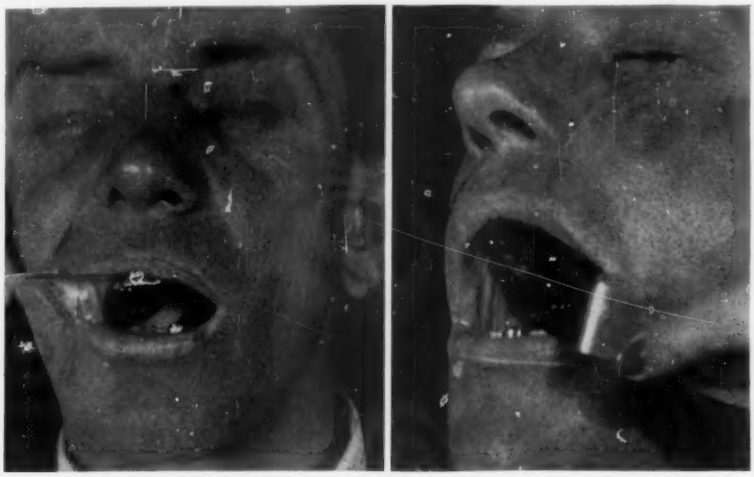

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FIG. 7.—Male, age 34. Several years previously a dynamite cap exploded in his mouth causing considerable destruction both inside and outside the cheek. Eventually, a dense scar band formed which prevented more than partial opening of the jaws. (1) Note the dense scar in the lining of the right cheek which partially obliterates the buccal sulcus above and below. The margin of this band can be seen. A Z-plastic was performed and relaxation obtained. (2) Follow-up at end of seven months. Note the ability to open the mouth and the condition of the cheek lining.

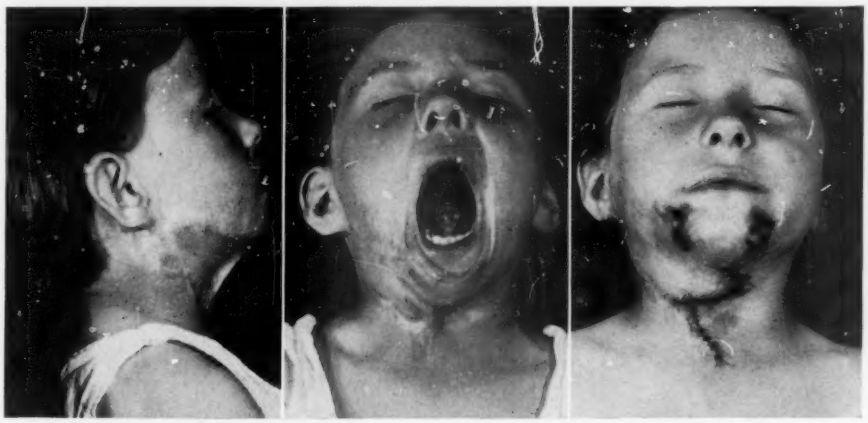

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FIG. 8.—(1 and 2) Scar bridle on neck at margin of flap set in a year previously for the relaxation of a broad contracted scar. Note the good condition of the flap. When the mouth is opened widely, there is a pucker-string scar around the mouth. (3) Several days after relaxation the scar bridle on the neck by a Z-plastic and relaxation of the pucker-string scar on each side of the chin with Zs.

mercuric iodid (kalmerid) 4 Gm. to 460 cc. of acetone, as it is effective and seems less irritating to the scar than other chemical preparations. Thorough scrubbing with green soap and water followed by ether and alcohol is often

the method of choice, especially on the hands and feet, and where there are numerous depressions and irregularities in the scar.

The details of the operative procedure described in this paper differ somewhat from that which we have published elsewhere, although the principle is the same.

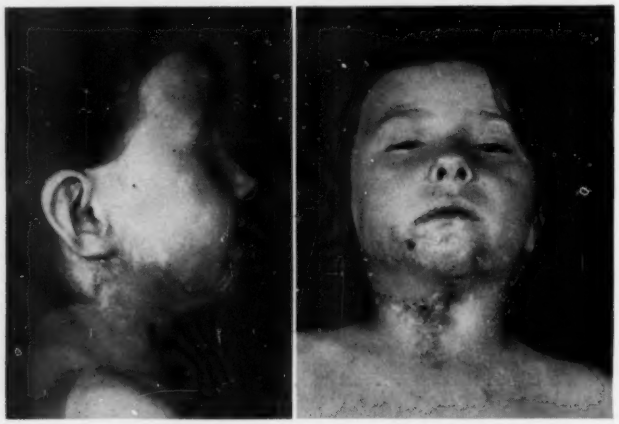

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FIG. 8 (continued).—(4 and 5) Ten days later. Note the relaxation of the web on the neck and the scars on the chin.

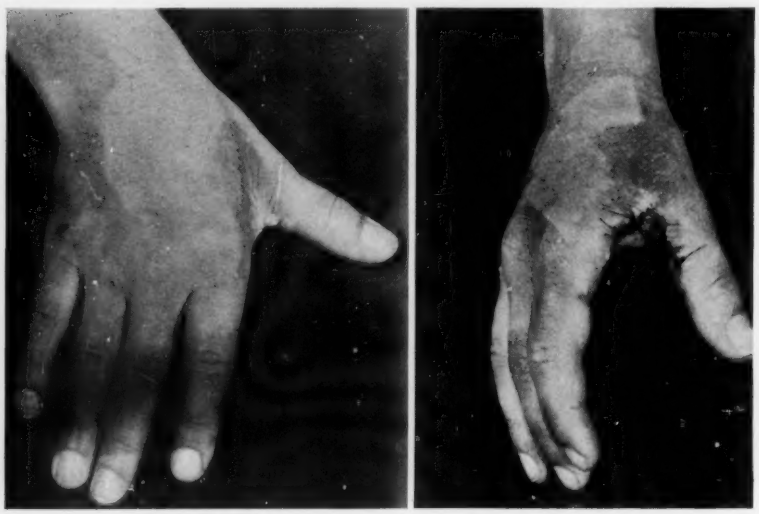

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Fig. 9.—(1) Rope burn scar of several months' duration. Web between thumb and forefinger replaced by scar which prevents full spread of thumb. (2) Stitches still in place after relaxing the scar web by a Z-incision and transposition of the scar flaps. Note the extent of relaxation.

Operativie Technic.—With the scar bridle under tension, the proposed incisions are marked out with 5 per cent brilliant green in alcohol. The central line of the Z is marked along the most prominent part of the bridle

or web, and the arms of the Z, which are of the same length as the central line, are laid out on opposite sides of the central line making the pattern an atypical Z or reversed Z depending on the condition of the surrounding tissues. The arms of the Z, being at each end of the central line on opposite sides, are drawn parallel to each other at about a 60° angle to the central line, as this has been found to be the most satisfactory angle for practical use.

Marking out the Z with the 60° angle can be facilitated by having among the instruments a piece of thin metal cut out with this angle, and having its edges marked with inches or centimeters so that the lines of the Z, which should be equal, can also be easily measured.

If unequal angles are used, the arm lines cannot be parallel to each other. When incisions are made following the Z pattern, two broad based triangular flaps result, whose bases are opposite each other. These flaps are undercut

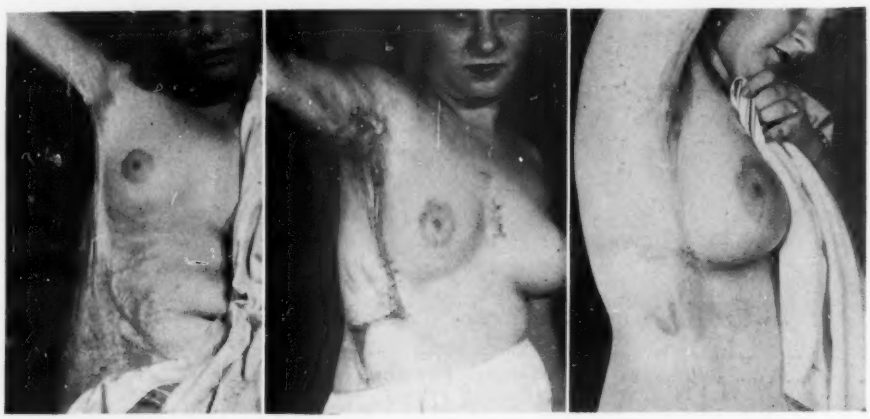

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FIG. 10.—(1) Female, age 9. Contracted burn scar from arm to thigh. Duration five years. Note the thick scar web when the arm is raised. The body is drawn to the right and there is interference with the development of the right breast. (2) Two months after the first attempt to relax the scar pull by a single large Z on the chest and abdominal wall, one in the axilla and three smaller Zs in the groin and on the thigh. (3) Follow-up at end of five years. Has gained considerably in weight and height. Note the difference in the appearance of the scars following the Z-plastics; also the development of the breast after relaxation of the scar.

and fully mobilized, and all binding scar tissue beneath is removed as completely as possible. When this is done, the ends of the central incision are drawn away from each other by scar pull; the central line becomes longer, and the angles become blunted. The flaps are then transposed so that their outer margins approximate and the tips of the flaps touch the outer corners of the bases of the opposite flaps. The flaps are then sutured without tension into their new positions with a few on-end mattress sutures of fine black waxed silk placed at strategic points, and the rest of the closure is made with similar sutures of horsehair. The sutured wound is also Z-shaped but the Z is turned through approximately 90°, is elongated, and the central line of the original Z now lies transversely across the scar pull. The elongation is the relaxation obtained by the shifting of the flaps, and this gain in length depends on the size of the Z and on the size of the angles at which the arm

lines are cut in relation to the central line. Lines projected across the bases of the triangles outlined by the Z before the incisions are made will form a parallelogram. The central line of the Z is the short diagonal, and a line joining the ends of the arm lines is the long diagonal of this parallelogram.

When the angles are unequal, lines projected across the bases of the triangles outlined by the Z will form a rhomboid. The central line of the Z in these figures is also the short diagonal, and the line joining the ends of the arm lines is the long diagonal. The amount of relaxation obtained is the difference between the lengths of the long and short diagonals of the parallelogram, or of the rhomboid, as the case may be.

Dressings.—The sutured wound is dressed with a single thickness of gauze impregnated with 3 per cent xeroform ointment over which are placed several thicknesses of dry gauze and a sterile seasponge wrung out thoroughly.

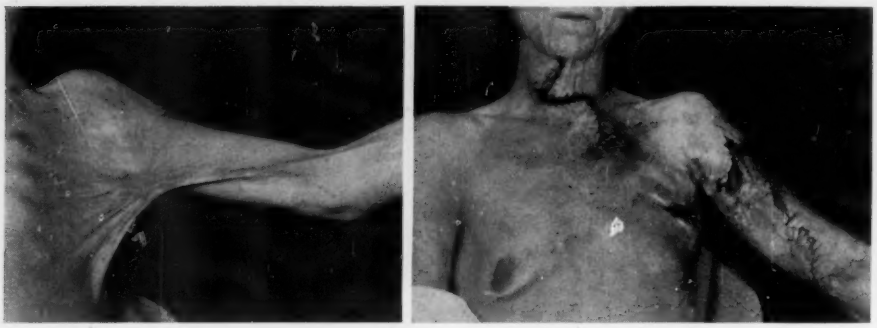

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FIG. 11.—(1) Female, age 24. Contracted burn scar with webs on neck, axilla and arm. Duration 21 years. (2) Five days after relaxation of the scar on the neck by a Z-plastic and the relaxation of the webs on the arm and axilla by single Zs and Zs in series. Note the irregular line of closure on the arm and in the axilla.

Even pressure is applied with adhesive plaster and a bandage. The part is immobilized. On the third or fourth day, stitches which have loosened are removed and the same seasponge, which now functions as a light cast, is replaced. The remaining stitches are removed as they loosen, and all are usually out by the tenth day. Massage is started after three weeks and is continued for several months.

Comments.—The ideal place for the use of the Z-incision with the transposition of the triangular flaps thus formed is in those instances where the skin is normal in texture, but where a web exists such as may be found in congenital webbing of the neck or popliteal space; also in certain cases of syndactylism and of congenital misplacement of normal surface levels. Such unscarred skin webs are, however, comparatively rare, and in the vast majority of instances where the procedure is used, the tissues are composed entirely of scar or of skin more or less infiltrated with scar.

If the scar bridle is reasonably thin and flexible, or is composed of only partially infiltrated skin, it is split and is utilized as part of the flaps. If, on the other hand, the scar bridle is thick and rigid and is unpromising for use

because of poor circulation, then an elongated ellipse of tissue, including this unusable portion, is excised and the edges are brought together with a few temporary sutures. This sutured wound is used as the central line of the Z, the arms of which are then marked out in the usual way.

When dealing with a deeply grooved scar, the same procedure is carried out, except that the central line of the Z splits the groove lengthwise, and the flaps are formed just as when a web is present.

When the Z-incision is used on the fingers, or the wrist, or in any region where there is scant tissue to bring in from the sides, then the flaps should be short. Tissues which have healed out of line, such as eyebrows, eyelids, corners of the mouth, *etc.*, may be replaced in normal position by means of the Z-incision with transposition of flaps.

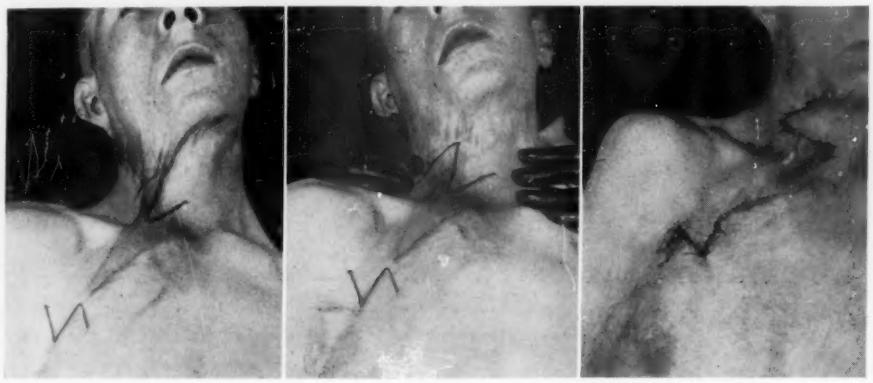

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FIG. 12.—Male, age 16. Contracted burn scar. Duration 14 years. (1) The proposed Zs were marked out before operation on the neck bridle and on the grooved scar on the chest. The Z on the neck measured 1¾ inches. The Z on the chest measured 1¼ inches.
(2) Shows the Z on the neck flattened out by lateral traction.
(3) Nine days after Z-plastics on neck and chest. Note stitches in place and superficial drying out of the tip of one of the flaps on the neck. The Z on the neck measured 3½ inches after transposition or relaxation of 1¾ inches. The Z on the chest after transposition measured 2½ inches, a relaxation of 1¼ inches.

The flaps should be handled with small sharp hooks to avoid bruising, and should be sutured without tension. The flaps should be blunt instead of pointed as when thus made, the tips are less liable to slough. When 60° and other usable angles are marked out and cut, the tips of the flaps become more blunt by immediate contraction. In order to assure circulation, it is advisable to have the flaps as thick as may be, including some subcutaneous fat, if available. When the flaps formed by the Z-incision are large and thick and made up of a considerable amount of fairly normal tissue, then a few deep sutures may be advisable for immobilization.

Sometimes the tips of the flaps become cyanotic after transposition. A few puncture wounds with a pointed knife may relieve this, but if this is not effective continuous compresses saturated with cold sterile normal salt solution may be helpful. Gentle massage toward the bases with the fingertips may be used, if necessary. The tips of dense scar flaps will sometimes slough,

but this slough is usually on the surface, and as it occurs after the relaxation is obtained by the transposition of the scar flaps, it does little subsequent harm as far as recontracture is concerned.

At times the contraction pull of the scar on the two sides of a central bridle or web may be quite different and consequently after the incisions have been made and the flaps have been formed and undercut, they may be drawn entirely away from the anticipated position. In these instances, readjustments by properly placed secondary incisions may be necessary and must be carried out before the desired relaxation can be obtained and the wound closed. Thus the final sutured wound in these cases may be a double Z or some other form of zigzag closure.

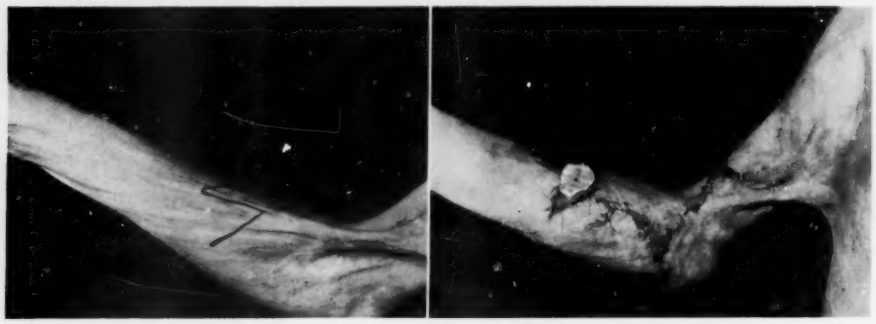

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FIG. 12 (continued).—(4 and 5) The contracted bridle on the forearm. The Z marked out measured 1⅝ inches before incision and transposition of flaps and 2¾ inches after transposition, a relaxation of 1⅛ inches. Further relaxation was effected above the marked-out Z, and the closure was a long zigzag.

In long contracted scars, say from the buttock to the ankle, or from the elbow to the hip, several Z-shaped relaxation incisions may be made in different portions of the scar bridle during the same anesthesia, but they should be placed so as not to interfere with the circulation of flaps already made and transposed. Another method of utilizing multiple Zs is to make a central line, and then mark out as many Zs as necessary in series. After the flaps are loosened and transposed, a zigzag closure results. When Zs in series are employed, the flaps must necessarily be short. This procedure was first used by Morestin.[4]

In a wide scar bridle, Z-incisions may, if necessary, be made and relaxation obtained in more than one place, and in more than one direction. The length of the flaps in Z-plastic relaxation incisions may vary from as little as 5 Mm. in the angle of the eye or mouth, to 15 or 20 cm. or more, on the chest or abdominal wall.

Measurements were taken in 70 Z-plastics, which may be grouped as follows—14 on the face; 22 on the neck; 12 in the axilla; nine on the arm; six on the wrist and seven on the forearm. The relaxation secured ranged from 50 to 100 per cent of the length of the central line of the Z. The series on the wrist areas ranged from 50 to 80 per cent and accounted for most of the lower

percentages. The rest ranged from 80 to 100 per cent. One can, therefore, be quite certain of a relaxation of at least one-half of the length of the central line of the Z.

The outlines of prospective flaps vary considerably in shape and direction depending on the scar pull and the amount of involvement. The best available tissue should be utilized in planning the flaps, and the bases of the triangles placed so as to include the least scarred and thickened skin. The difficulty with marking out and following accurate geometrical figures is that the texture of the tissues making up the flaps varies greatly, some being made up of fairly flexible material and others being so heavily infiltrated with scar or entirely made up of scar tissue that they have but little flexibility. The location of the scar and the contour of the part must also be considered. However, with properly placed central lines, with arms at workable angles, we can plan the amount of relaxation quite accurately.

While the triangular flaps marked out in a typical Z-incision with equal angles are approximately of the same size, in certain instances the angles must necessarily be unequal on account of physical conditions. Consequently, the triangles are of unequal size, but the outlining incisions must be of equal length in order to make transposition practical. In these cases, the closure is an atypical Z, and the relaxation is not as great as if the triangles were of the same size.

In those cases where the desired relaxation has not been obtained by the first Z-plastic, after six months have elapsed, and the tissues have been softened and the circulation improved by massage, *etc.*, the same area in which the Z-plastic relaxation operation was previously done can be further relaxed by a similar procedure. We have carried this out with satisfaction in many instances.

In children, after a Z-plastic has been performed, the procedure may have to be repeated from time to time as the child grows, as scar stretches but little. It must be remembered, however, that in similar contractures in children treated by excision followed by the use of thick or thin Ollier-Thiersch grafts or by whole thickness grafts, that the grafted area contracts and that the grafts do not increase in size in proportion as the growth goes on. In consequence, partial recontracture, especially of the graft margins, may take place, which may have to be relieved by either further excision and grafting, or eventually by Z-plastics.

In the growing period a contracted scar which is not relieved may interfere with bone growth or may distort the bone if it continues to grow. In an adult, a contracted scar may cause atrophy of the bone by disuse, and this fact must be borne in mind when manipulating a part such as an arm immediately after relaxation by a Z-plastic, as a fracture may easily occur. After relaxation, function is usually restored, and the bone in both children and in adults, in time, ordinarily regains its normal shape, appearance and strength.

SUMMARY.—The name Z-plastic is given to the method because the out-

line of the incision is roughly that of a Z. The maneuver is based on the transposition of two triangular flaps whose angles may be equal or unequal.

It has been demonstrated by Limberg that for practical purposes, the Z should be cut with angles not larger than 60° and not less than 20°, because when the incisions are made, the wound immediately spreads, the length of the central line becomes longer and the angles become larger. For instance, when a Z with 60° angles is cut, the angles become about 76°, and when a Z with 20° angles is cut, the angles become about 36°. Where it is possible, 60° angles are chosen, as they give maximum relaxation. The actual length of the central line and the arm lines, all of which should be equal, depends on the location of the area involved and on the condition of the tissues. When the smaller angles are used, the length of the incisions making the Z should be short. With the angles properly laid out, one can determine quite accurately the amount of relaxation which will be obtained before the incision is made. This can be computed by taking the difference between the length of the long and short diagonals of the parallelogram made by projecting lines across the bases of the triangles marked out by the Z. The actual amount of relaxation varies between 50 and 100 per cent of the length of the central line of the Z.

By the use of Z-shaped relaxation incisions with the transposition of the flaps thus made, satisfactory and effective relaxation can be accomplished in contracted scars with bridles, or webs, or grooves. Scar flaps, which would otherwise have to be excised, are utilized and are transposed and sutured in their new positions, thus immediately closing the defect. In other words, in suitable cases, the utilization of the method will avoid the necessity of skin grafting or flap shifting from a distant part. In time, after relaxation has taken place, the nutrition of the shifted scar and adjacent relaxed scar improves, and it becomes softer and is a useful factor in the final result. The suture line after transposition is as a rule Z-shaped but the Z is turned through approximately 90°, and the central line of the original Z lies transversely across the line of the scar pull and prevents recontraction. The success of the method depends on the presence of lax tissue which can be drawn in from the sides.

The method has greatly simplified the problem of scar relaxation in many cases which would otherwise have had to undergo a much more extensive operative procedure to obtain relief, and we prefer it to skin grafting in practically every situation in which it can be used.

Unless one is familiar with the procedure and its possibilities, it is difficult to realize how much permanent relaxation can be obtained by the Z-incision with the utilization of transposed triangular scar flaps. In many instances, we have been able to restore function and return patients, either partially or completely incapacitated to their ordinary occupations. We have used the Z-type incision with increasing satisfaction for many years on a large number of cases on every part of the body and find it one of the most generally helpful maneuvers in our armamentarium.

CONCLUSIONS

In our experience in suitable cases, the operative procedure of the Z-plastic is simpler than other methods for relaxing scar contractures; tissues are successfully utilized which would otherwise be discarded; the appearance of an area relaxed by this method compares very favorably with that of other methods; additional scarring of unscarred areas is avoided; contractions can be permanently relieved by this method which would be difficult or impractical to correct by skin grafting. The results are so satisfactory that we are using Z-plastics more and more for the shifting of triangular flaps of scar infiltrated tissues and also of normal tissues when available, in all parts of the body.

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THE UTILIZATION OF THE TEMPORAL MUSCLE AND FASCIA IN FACIAL PARALYSIS

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THE temporal muscle and fascia can be utilized to give anchorage for fascial strips in facial paralysis, and some degree of emotional expression may be developed, if the patient will train the newly substituted fifth nerve muscle and will avoid overactivity of the sound side of the face (Figs. 1, 2 and 3).

Mechanical support, of course, should not be relied upon when nerve anastomosis is possible; but, where the distal branches of the nerve have been torn out—in partial paralysis where it is thought definitely best not to disturb the function already present—and in congenital paralysis, the operation outlined herein is applicable.

Summary of Previous Work.—For direct nerve suture and free nerve transplant, the work of Ballance and Duell has developed much interest in the past few years. Anastomosis with other motor nerves has been effected by many surgeons and the photographs of patients that showed excellent emotional expression have been recorded.

Eden, in 1911, and Gillies, in 1917, used strips of temporal fascia turned downward over the zygoma to support the face. J. S. Davis, in 1911, and Gallie and Le Mesieur, in 1923, published the results of extensive work on the free transplantation of fascia, and the first report of free fascial strips to support the paralyzed face was made by Blair in 1926. Since this time, descriptions have been made of various methods of fixation of the fascial strips, of use of the opposite frontalis and of flaps of the masseter and temporal muscles from the same side.

Operation for Combining Temporal Muscle and Free Fascia Support.—After consideration and observation of these different methods, a combination plan of operation was developed, in which free fascial strips are put subcutaneously through the face and are anchored directly into the temporal muscle and fascia through an opening in the temporal region (hair-bearing area) (Figs. 1 and 2).

Technic of Obtaining Fascia.—Careful removal of very long strips of fascia lata is accomplished with the Masson or other suitable stripper. An incision is made above the knee about 6 cm. long, and the subcutaneous tissue is carefully separated from the fascia upwards, the length of the dissecting scissors; this separation helps in getting the stripper started. At times there are a good many transverse fibers as a separate layer over the longitudinal fibers, and these can be opened through, as they are of no benefit and hinder the action of the stripper. Three or more strips about 1 cm. wide are re-

moved, it being very advantageous to have them long enough for a complete loop through the face and anchorage in the muscle. Therefore, the removal is started quite low and carried all the way up to the tensor fascia femoris. The 1 cm. width may seem wide, but when it rolls up on manipulation, its bulk does not seem too great.

The leg wound is closed without drainage and a firm bandage put on through the full length of the fascial removal. No objective or subjective trouble has been noted by the author, although others have reported occasional trouble with muscle herniation.

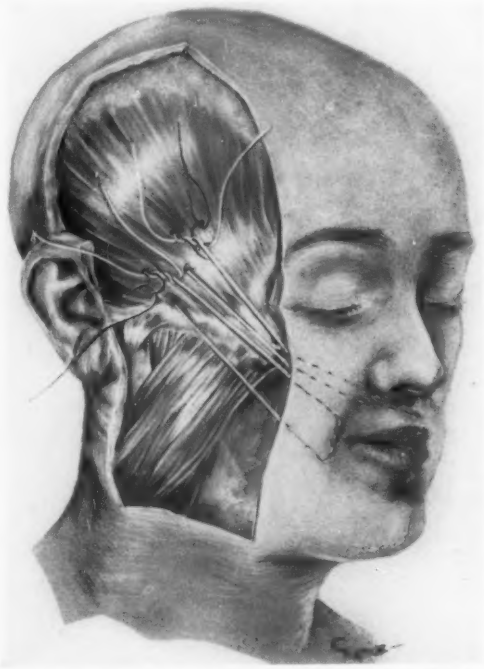


FIG. 1.—Diagram of the free fascial loops' course through the face and fixation in the temporal muscle.

It is possible to use homografts of fascia successfully, and preserved fascia has been employed, but the operation for removal of autografts is simple enough to warrant their use routinely.

Operation on Face.—Diagrammatic course of the fascial strips is shown in Figure 1, and the scar of operation in Figure 2-E.

A slightly curved incision is made in the hair-bearing temporal region about 6 cm. long, and the temporal fascia is almost completely exposed by retraction.

With a long needle, a loop of fascia is threaded from this wound through the subcutaneous tissues of the face and back up through a second different channel into the temporal wound again. To make the loop on the upper lip the needle is brought out through a stab hole in the philtrum or a little to

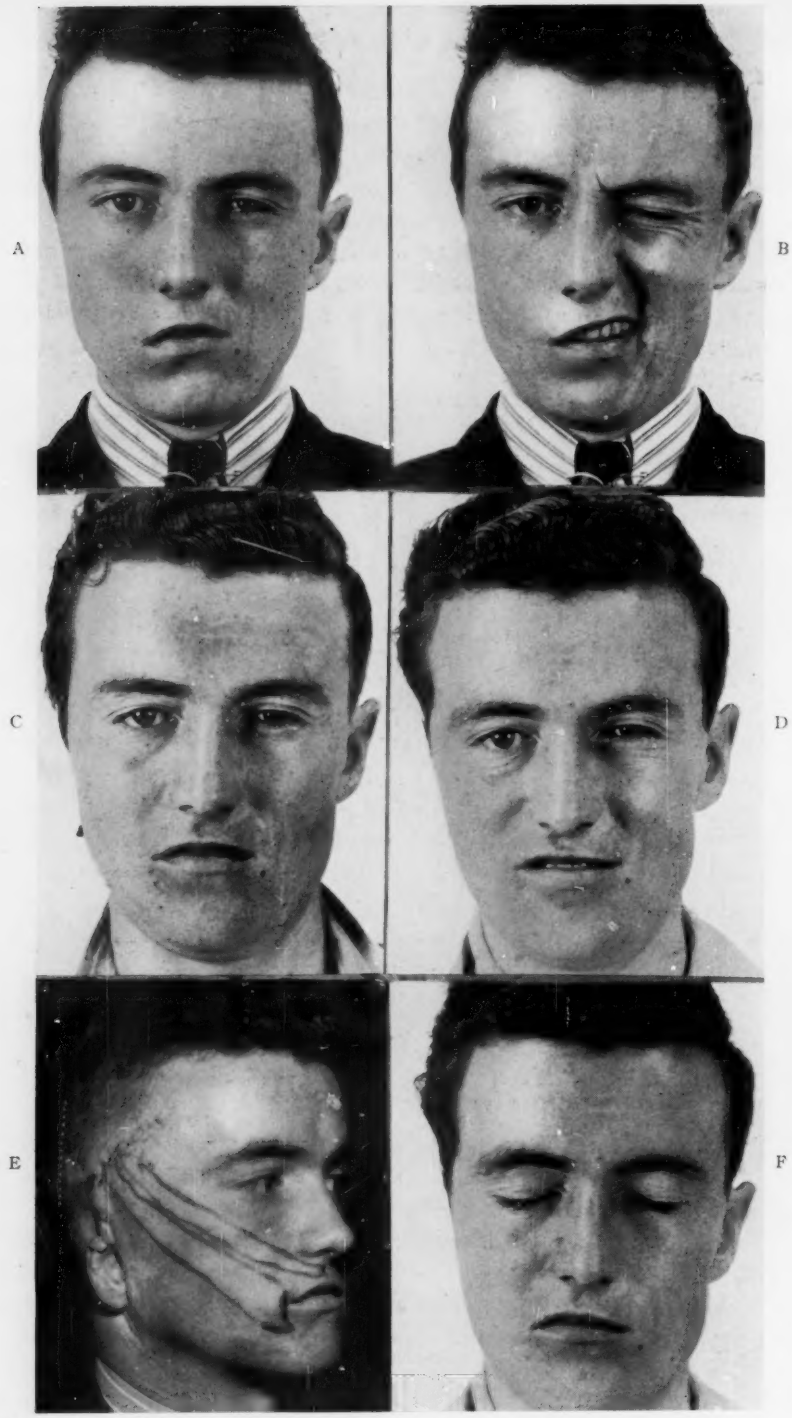


FIG. 2.—(A, B) Traumatic facial paralysis in which nerve repair was impossible.
(C, D) Result of one stage operation as described here, with good facial level and some emotional expression. Patient stated that he attended college with very few persons knowing his face was paralyzed.
(E) Operation scar and course of tendons through face.
(F) Good closure of eye, obtained by elevating face without putting separate fascial loop through lid. This is also helped by performing the operation before excessive sagging has taken place. (The flap on the neck is for reconstruction of the ear.)

the opposite side. The two courses of the needle through the face are easier if made from above downward. The two ends of the fascia can now be worked back and forth in the temporal wound to establish their firmness and then the lip position can be held straight by the loop. A second loop is

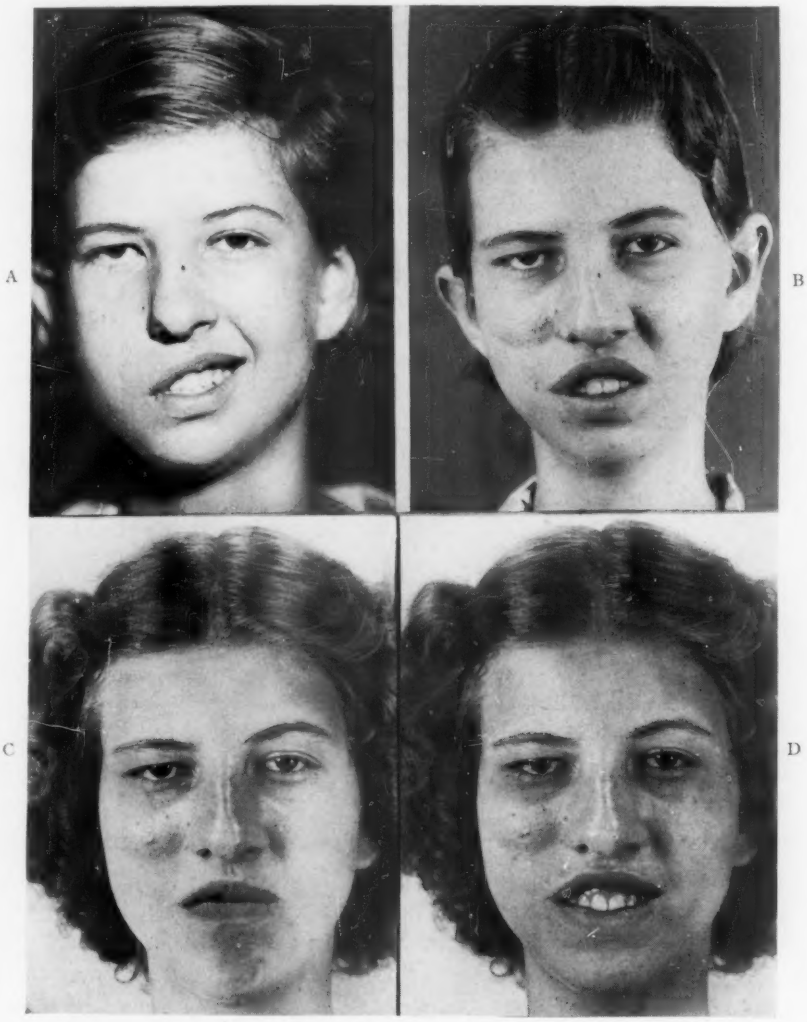


FIG. 3.—(A) Complete facial paralysis—congenital.
(B) Result of the described operation showing motor power of the (fifth nerve) temporal muscle elevating the lip in a slight smile to give some degree of emotional expression.
(C, D) Later photographs to show persistence of result and also improvement in control of the face and in emotional expression.

now put in as illustrated with an extra curve around the angle of the mouth and, in heavily drooped faces, other loops may be necessary to the ala and farther across under the lower lip.

Anchorage in the Temporal Muscle.—When all loops are in place, one

strand of each is carried through the temporal fascia all the way down through the muscle and out again through the fascia 1 to 2 cm. distance. The loops are then pulled tight to over-correct the face quite noticeably, the first part of a surgeon's knot is put in the loops and they are clamped with two mosquito forceps. Then fixation is firmly effected with three or four No. 000 silk sutures put through the loops and tied around them. An effort should be made to get a secure hold on the muscle in a region where there is the most movement and this is close to the attachment to the coronoid. It might be thought best to completely free the tendon from the coronoid and bring it out for direct attachment to the fascial strips, but this simpler procedure should suffice and the nerve supply is less apt to be sacrificed. (Turning

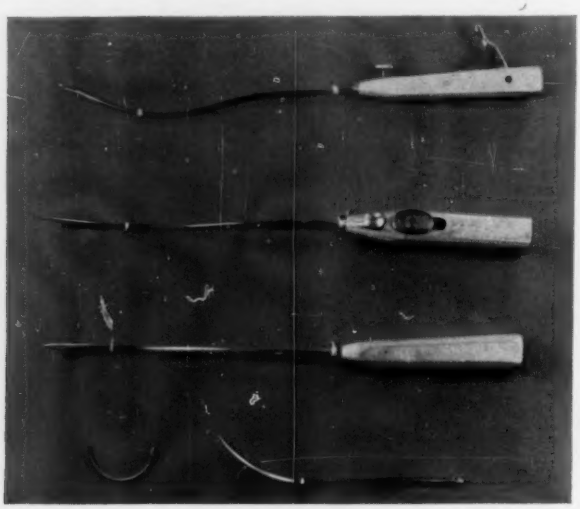


FIG. 4.—Various needles for threading fascia through face. First and third: Type of needles used by Blair. Second: A modification of the first needle by Smith. Below: A long postmortem type of needle for going through face and a full curved fascial suture needle for anchorage in the temporal muscle.

muscle flaps down from the parietal bone seems quite apt to damage the nerve supply) Figs. 1 and 2-E.

The needles used are illustrated in Figure 4, and it is best to have an eye in the pointed end as there is in the Reverdin needle and in the hollow-tube type used by Blair. If the postmortem type is used, the fascia may have to be attached to it with a long, heavy thread and this needle has to be threaded through, one time, from the lip to the temporal region.

For putting the loops into the muscle a needle of the Reverdin type can be used, or one of the heavy, full-curved fascial type, as illustrated, makes a good curve into the depth of the fossa.

Fascial loops for elevating the lower eyelid are not put deep into the muscle but are fastened into the temporal fascia as the approximation of the lid to the globe should be present at all times and not depend on any conscious muscle activity.

When the fascial loops are all completed, the skin flap is closed, and at this stage if there is much excess skin present, as there is apt to be in long-standing cases, it may be excised along the margin after pulling the anterior flap up tightly and determining the amount of excess. This will necessitate extending the incision down over the crus of the helix and tragus and undermining the skin quite far out on the cheek. When this is all accomplished, the result is that the deep tissues are elevated and attached to the masseter muscle; the excess facial skin has been excised and the skin reattached to the scalp for fixation. There is almost always better approximation of the lower lid to the globe because of the elevated face, even if there has been no tendon loop put in the lower lid (Figs. 2 and 3).

Badly drooped cheeks in patients with thick skin and subcutaneous tissue may need to have the excess skin removed at a second operation because it sometimes has to be elevated so far and the wound edges held so tight that healing is delayed; and that is, of course, not desirable over the freshly transplanted tendons. For this reason, if possible, the operation for support of the face should be performed before marked sagging has taken place.

Tendon transplants do not stand infection well and every effort should be made for a clean operation even though it is carried out right at the mouth opening. Intratracheal anesthesia with the tube coming out the opposite angle of the mouth is probably the best.

Postoperative Course.—A large pressure dressing, using either marine sponges or fluffed mechanic's waste, is put over the entire side of the face including the eye, after strapping it shut with adhesive. Chewing is prohibited. After several days the face can be held supported with collodion and fine mesh gauze which is fastened along the lips and cheeks and then in the temporal region above the incision. This can be kept on two to three weeks and then activity allowed. There may be a long period of swelling and the overcorrection may seem annoying, but secondary adjustments are usually for tightening rather than loosening the tendons.

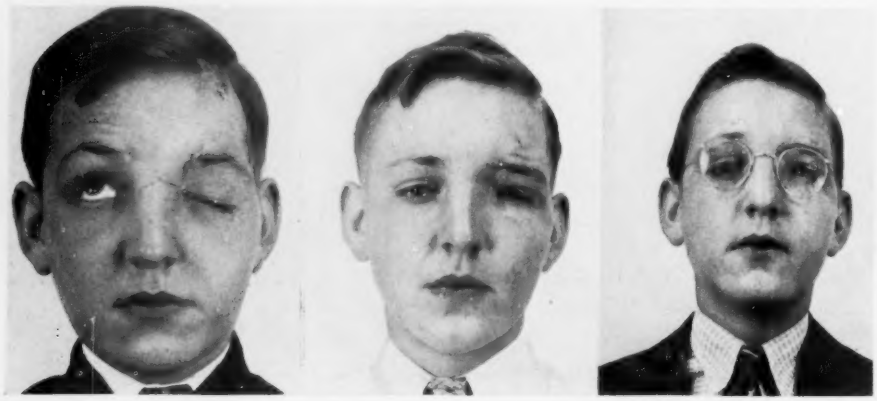
Results of Surgical Treatment.—With subsidence of the swelling, the face usually smooths out and the tendons can be felt in the cheek. Electrical stimulation of the facial muscles can be maintained if desired, but, if the tendons work well, the tone of the face seems to be satisfactory. After some weeks, the conscious muscle activity of setting the closing muscles of the jaw should come into play and give some degree of emotional expression (Figs. 2 and 3).

Facial Muscle and Speech Training.—One of the most important points, for a successful outcome, is that the patient should train his facial movements. This includes the use of the newly attached fifth nerve muscle which will produce a slight smile and a nasolabial fold on a slight setting action of this closing muscle; and, of equal importance, is learning not to overact on the sound side. It seems that many people with facial paralysis, in speech and laughter, throw about twice as much movement into the sound side of the face as they probably would if both sides were working. Therefore, a fun-

damental of the training might be for these patients to try to become rather "glum," and work from this point towards a limited movement on the sound side and an involuntary or subconscious setting of the fifth nerve muscles on the repaired side, in smiling. Of course, sudden emotions will always register mainly on the sound side; there is probably no way of controlling this, and it would be the same even with a successful nerve anastomosis.

If there are other speech defects, such as lisping, training by a professional should be of great value, because everything that will help to prevent other persons noticing the face of one of these patients is desirable.

Eye Involvements.—As has been mentioned before, some elevation of sagged lower lid is obtained by the operation on the face (Fig. 2-F). If it needs further support, a single fascial loop can be put through the lid and



A B C

FIG. 5.—(A) Complete ptosis of the upper lid, from a third nerve lesion and paralysis of the frontalis (seventh nerve) muscle from the local scar.
(B and C) Elevation and some degree of emotional expression in the lid by attachment of lid to the forehead with fascia and by a second loop of fascia from the temporal fascia through the tarsus to the opposite functioning frontalis.

held on each end, above in the opposite frontalis—which may give some slight emotional expression—and on the outside in the temporal fascia.

Heavy drooping brows may be raised by extending the skin incision over the forehead, undermining down to the brow, elevating and excising the excess skin, and reattaching it to the scalp.

For the apparent exophthalmos a small external canthoplasty can be performed to narrow the opening. Cervical sympathectomy has been recommended to proceduce the enophthalmos of a Horner's syndrome, but this procedure would be contraindicated if there were already a heavy overcast eyebrow.

When ptosis of the upper lid exists with seventh nerve paralysis, the problem of getting the lid elevated becomes very acute. If an extra-ocular muscle operation will not suffice, the lid can be elevated with a single loop of fascia from the temporal fascia, through the tarsal border of the lid, across to the opposite frontalis. An extra loop may be necessary to help in the

elevation and may be attached above to the inert tissue in the forehead. This implies that the lid will be held open all the time, and trouble with the cornea will result if it is not kept protected carefully (Fig. 5).

The use of fifth nerve muscles is not recommended in trying to get elevation of the upper lid because of giving movements that would appear too gross and too conscious.

DISCUSSION.—DR. WALTER E. DANDY (Baltimore, Md.): I have been very much impressed with the brilliant results of Doctor Brown in this field. His contribution is, I think, the insertion of the fascia into the temporal muscle. I have often wondered whether this might not be a better treatment of those cases of facial paralysis where a nerve transplant is the usual procedure. I wonder if these results may not actually be superior to an anastomosis of the spinal accessory or hypoglossal nerves which would then not be sacrificed. Certainly the results are very good. I have performed a few of them and have been much impressed with the muscular control which one can get through the use of the temporal muscle.

DR. JAMES BARRETT BROWN (St. Louis, Mo., in closing): I am not qualified to evaluate the end-results of nerve anastomosis, but many very worthwhile results have been published. In those patients not suitable for nerve anastomosis, the operation described here may give the most satisfactory result.

There have been descriptions of fifth nerve muscle flaps from the temporal and masseter to the eyelids, but when approximation of the lid to the globe is such a constant necessity, it seems improbable that fifth nerve muscles would afford much comfort. It is probably best to fasten support in the temporal fascia, carry it through the lid and anchor it near midline or even up in the opposite frontalis.

TREATMENT OF SCIATIC SYNDROME BY ILIOTIBIAL FASCIAL BAND SECTION

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HOUSTON, TEX.

THE phrase "sciatic syndrome" in this paper will include those cases which have pain radiating along the course of the sciatic nerve, many of which are associated with low back pain.

This group of 20 cases does not represent all cases of sciatica and low back pain treated in our clinic, but only a very small percentage: to be exact, only 20 per cent of cases seen since 1935. No claim for originality is made for the method of treatment used, as you will all recognize it as the Ober method, which has been severely criticized by some members of the profession, but, in our opinion, unjustly.

My attention was first called to this method of treatment by an article by Doctor Ober,[1] in 1935, captioned "In Defense of the Fascia Lata and Iliotibial Band Section," in which his explanation seemed so plausible that we decided to adopt the technic, in an effort to relieve some of our cases which had not responded to all other methods with which we were familiar.

However, before using this method we felt that a study of the function of the fascia should be made. We finally convinced ourselves that, for the most part, iliotibial tract functions as does deep fascia in most any other part of the body, namely:

(1) It helps provide fascial sheaths for muscles.

(2) It sends in wide sheets that form partitions or septa among the muscles.

(3) It helps form sheaths for vessels and nerves that lie among muscles.

(4) Parts of certain muscles are attached to the fascia.

(5) It helps to retain muscles in their places so that when they contract they pull upon the part of the muscle to be acted upon most effectually. (Knight.)

Also the iliotibial tract serves as an aponeurotic tendon by means of which the gluteus maximus and the tensor fasciae latae, the two muscles inserted into it, gain insertion into the lateral condyle of the tibia and the whole tract serves as a powerful brace which, in the erect position, helps to steady the pelvis and keeps the knee joint fully extended. (Cunningham.)

At first glance one might think that section of the fascia would materially interfere with the strength and proper function of the group of muscles served by the iliotibial fascia, but such is not the case.

The findings in our cases are very definite but we have been able to demonstrate the Ober sign in only a small percentage of our cases. In our cases the patient complained of low back pain in the region of sacro-iliac articulation, and pain following the course of the sciatic nerve; and any motion of the

leg which caused a strain on sacro-iliac articulation or stretched the sciatic nerve increased this pain. On examination the iliotibial fascia, along its attachment to the crest of the ilium, was found to be very tense and the slightest pressure caused the patient to complain of severe pain. When cases showing such a symptom-complex presented themselves in our clinic, they were carefully examined by our medical staff, who would clear up all foci of infection and then treat them; but if their treatment failed to cure the patient, they were referred to our department for further handling, and the group reported were treated by iliotibial fasciotomy.

The technic is very simple. The patient is placed on his side, the affected side up; then under local anesthesia, an incision is made extending from the iliac crest down to the great trochanter in line with the long axis of the femur. The incision is then retracted, and the fascia anesthetized and cut entirely across, thus severing its attachment to the iliac crest; hemostasis is established, the skin closed, a tight dressing is placed over the wound and the patient returned to his bed where he is kept three or four days; he is then allowed to get up and go home, if he desires. Sutures are removed on the sixth day and patient is allowed to go to his office, but the laborers are kept off work for ten days or two weeks.

ILLUSTRATIVE CASE REPORTS

Case 1.—No. 38362: G. N., white, age 33, bridge builder, had complained of pain in low lumbar region, referred down back of right leg since February, 1938. The pain was constant, severe, accentuated by exercise, and was so painful that he was unable to work. Search for foci of infection was negative, and there was no evidence of spondylolisthesis or sacro-iliac arthritis. During this period he received diathermy, large doses of salicylates, and attenuated streptococcal vaccine. He was operated upon under a local anaesthetic, May 2, 1938, and was allowed up on the third day. He was dismissed from hospital on the fourth day. He returned to work, June 1, 1938.

Case 2.—No. 28152: S. L. S., white, age 30, machinist. Eight months prior to admission to hospital he developed some slight pain in left hip region, which was not constant and varied in intensity. This pain gradually increased in severity and for two months prior to admission to hospital the pain was referred down the left leg and lateral border of left foot. The pain was worse on standing and was relieved by sitting, or lying with knees flexed on abdomen. He was treated in O. P. D. where a careful search for foci of infection was made. Complete examination revealed nothing except a second bicuspid root with periapical abscess; this was extracted with no evident improvement. No arthritis of the spine was found nor other evident causes of the back pain. A fasciotomy on the left side was performed, October 17, 1938. He stated on the table that he had immediate relief from his pain in left leg. He remained in bed five days. At time of dismissal he still had some discomfort along lateral border of left foot; this cleared up in about ten days.

Case 3.—No. 34304: R. D. H., white, age 38, section foreman, had had sciatic neuralgia from time to time for three years prior to section of band. He had been studied carefully on two occasions for foci of infection, and all of those discovered were removed, including tonsils and several teeth. The sciatic nerves of both legs had been injected two or three times with novocain and normal saline with transient relief. On October 16, 1935, section of right iliotibial band was performed, which gave him complete relief on that side. He was allowed up in seven days and returned to work in 16 days. He was free of pain for four months when the left side began giving him trouble. He

returned to hospital, at which time section of the left iliotibial band was performed. He has had four hospital admissions since that time for other causes, but has never had any difficulty with either his back or legs since the last operation.

We had two cases whose sacro-iliac pain was not entirely relieved by fasciotomy, and these were treated further in the Out-Patient Clinic by injecting and manipulating their sacro-iliac articulations according to the Haldeman-Soto Hall method, which seemed to relax the joint and entirely relieved both these cases. To-day, we have treated 20 cases and have 20 cures. It is to be remembered that in this group were included only those intractable cases which had resisted all treatment and were a constant reminder that we had failed in our efforts to relieve their disabilities.

In conclusion, I agree with Doctor Ober when he said: "It has been stated that division of the fascia lata and the iliotibial band, as advocated, does not relieve lame backs." The writer's experience is quite different, and what is more convincing is the fact that most of these patients operated upon at our clinic voluntarily stated that there was a great deal of relief of the back pain, even on the operating table, immediately after the fasciotomy.

In my 28 years of practice, I have never employed a technic in the treatment of any lesion which has given results comparable to those obtained in this series, and I recommend it to the serious consideration of everyone, including its critics. It is not only a blessing to those poor unfortunates who have fallen victims to this malady, but a solace to doctors who heretofore have been forced to face these patients day after day begging for relief. In our hands this has been such a satisfactory procedure that I wish to call it to the attention of this Society in the interest of those suffering with this type of malady.

REFERENCE

[1] Ober: J.A.M.A., **105**, 1136–1137, October 5, 1935.

DISCUSSION.—DR. FRANK DICKSON (Kansas City, Mo.): This question of persistent low back pain is so vexing that any procedure that offers a reasonable expectation of relief is certainly worthy of consideration. I believe firmly in the procedure of fasciotomy for the correction of a demonstrated contracted fascia lata. We have performed 87 fasciotomies in the past few years, 50 of which were for persistent low back pain, with the following results in the 50 low back cases: Recoveries, 35; failures, 12; too recent to determine, 2; questionable, 1. This one can now be put in the cured list.

The chief drawback to the procedure is that it is so simple that it is very likely to become too attractive. Fasciotomy should not be performed without first eliminating from the picture certain conditions of the sacro-iliac and lumbosacral joints, and certain congenital abnormalities of the lumbosacral region. In addition to this, I believe there are certain definite diagnostic criteria which can be laid down. The following findings we have found of use: Tenderness in these cases is not over the sacro-iliac joint but lateral to it, over the pyriformis muscle. The sacro-iliac joint has a definite anatomic

position, and tenderness over it is elicited over the joint itself. In most of these cases the pain complained of is referred along the peroneal branch of the sciatic nerve; occasionally over the crest of the tibia. A positive Ober sign is believed essential. This sign is elicited by having the patient lie on the sound side with the knees flexed and held firmly in this position; the thigh on the involved side is then flexed to a right angle on the trunk and the knee to a right angle on the thigh, and the extremity abducted and extended. If the thigh does not adduct so that it drops to the examining table the sign is considered positive.

Doctor Green discussed the importance of doing a thorough division of the contracted and thickened fascia. Our experience has been that more than this is often necessary. The fascial septi between the individual muscles must be thoroughly divided in most cases to secure complete relaxation. Particularly is it important to divide the sheath of the sartorius muscle entirely, going completely around the muscle to do this.

From our experience with the operation of fasciotomy, we can confidently recommend it in properly selected cases. It is not a cure-all for low back pain. As in all physical procedures, there must be a clear-cut indication before it is done.

DR. CHARLES C. GREEN (Houston, Tex., closing): I want to stress one thing that Doctor Dickson said. Doctors are inclined to be overenthusiastic over any new procedure, and I believe the proper selection of cases is 75 per cent of the battle. If you find a definite indication for the operation, you can perform it in the office; but I cannot follow him all the way, namely, that we should not operate upon those that do not have the Ober sign. We would have operated upon only about five patients had we limited the operation to such cases. Here the picture is definite: a sacro-iliac pain radiating down the course of the nerve, and everything that the medical staff can do has been done. In such cases we feel we are justified in performing a fasciotomy. It saves a lot of headaches in the medical department, and gives a great deal of relief to patients who heretofore have not been relieved.

NEUROLOGIC ASPECTS OF LOW BACK PAIN AND SCIATICA

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THE causes of low back pain and sciatica are many: they have long been the problem of the orthopedic and gynecologic surgeons. Up until 1934, the neurologic surgeons' problems were, in the greater number of instances, concerned with the diagnosis and treatment of spinal cord tumors. In 1934, Mixter and Barr[1] reported 19 surgically treated cases of rupture of the intervertebral disk with involvement of the spinal canal. Prior to this contribution, there are a few individual case reports of spinal cartilage protrusions; the symptomatology of which, in every case, simulated tumors of the spinal cord. Since Mixter's[1, 2] publications, many articles have been written on the subject of low back pain and sciatica as caused by these disk herniations, and at present over 300 operated cases may be found in the literature. As stated by Ghormley:[3] "The lesion has been established, and many more patients are now being promptly relieved by surgical treatment than were relieved formerly." In a personal[4] experience of 31 consecutive cases of chronic back pain and sciatica, studied with lipiodol, a displacement of the intervertebral cartilage into the spinal canal was visualized under the fluoroscope in 24 cases. This evidenced that such lesions were much more common than any of the publications on the subject had indicated. Since these earlier experiences, the low back pain problem has become more complicated, lipiodol investigations have been less, and the personal knowledge of the etiologic causes for low back pain has tremendously increased.

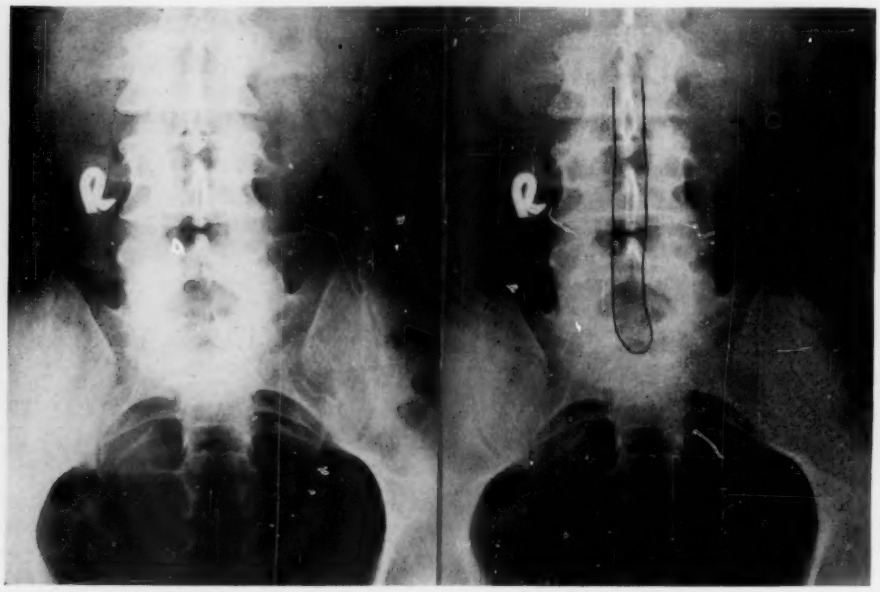
The symptomatology of the herniated disk is thoroughly reviewed in many papers on the subject. One of the most valuable experiences in the low back pain cases, seen in the past two and one-half years, has been in the development of a complete medical history. This sounds somewhat didactic, but the information gained from these histories has in many instances furnished the clue which has led to the establishment of an accurate diagnosis. The history of a surgically removed mole which had been reported histologically as benign suggested in one instance the possibility of a metastatic malignancy. This diagnosis was later supported by roentgenologic studies of the lumbar vertebrae, and biopsy of an enlarged inguinal node established the diagnosis of a melanoma. This particular robust patient twisted his body while lifting a heavy office desk, felt his back "snap," and there followed a typical incapacitating low back, sciatic pain. Another history that gave a definite "lead" to the correct diagnosis, was that of a bullet wound of the thigh, with a wound of entrance only. Twenty years had elapsed and the patient developed a chronic sciatica. Roentgenograms, primarily for localization of the bullet, showed it embedded in a chronic osteomyelitis of the femur. This patient's history of his sciatic pain did not vary from that of a "typical disk" case, for his pain radiated

through the thigh and into the calf of the leg and outer side of the foot. It was only when he was questioned specifically, referable to any injury, that the story of the bullet wound was elicited. These are two illustrations of several experiences in which a detailed history has helped in differentiating other causes of low back pain from the propulsed intervertebral cartilage. As far as the histories of the pain and discomforts from which the "disk" patients suffer are concerned, there is no classic story. In 70 per cent of 50 cases, in which a protruded vertebral cartilage has been removed from the spinal canal, there was a history of a specific injury which initiated their discomforts. There were 11 cases in which the type of the patients' work or daily activities were of such a character as would be conducive to low back injury. There was nothing in the clinical histories of the other four of these 50 cases to account for their cartilage displacements. In a relatively small percentage of the cases, was there a history of subjective numbness. Four patients gave a definite history of bladder and rectal sphincter losses. There was a history of "foot drop" in two cases, being bilateral in one instance. There was a history of unilateral postural ankle edema in six cases. With a variable location of their discomforts in these patients, the only consistent history that they all have had, has been a story of pain in the back. Additional discomforts have been numerous, involving one or both lower extremities, localized to the hip region, the posterior thigh, the lateral calf, the external malleolar region, in combined or complete patterns.

The variability in the neurologic findings has been almost as great as have been in the subjective symptoms. The one finding that has been present in all of the 50 operated cases, has been a tenderness on pressure in the interspace between the posterior spines at the level of the disk protrusion. This has been a maximal painful area and in most cases was the only point of elicited interspinal pain. In a few instances, pressure in the interspace above and below the space of the level of the lesion has produced some discomfort. All of the 50 cases have had some one or more positive neurologic findings. The objective symptomatology has varied from a single diminished tendo achillis reflex to a complete destruction of all forms of sensation, muscle atrophies and sphincter dysfunctions. Segmental sensory changes have been found in 84 per cent of the operated cases and almost an equal percentage had changes in reflex activity. Forty per cent of the total cases had motor root symptoms in the nature of measurable atrophies or fibrillary twitchings. What has been said in reference to the neurologic findings in these operated cases is not true for all cases of herniated cartilages, for there is a small percentage of cases in which there are no neurologic manifestations other than the subjective story of pain. There have been two such cases in over 140 instances of low back pain and sciatica, in which the lesions were depicted elsewhere on further investigative studies than clinical examination. Both were proven herniations at operation.

Earlier experiences in filling the lumbosacral subarachnoid space with air and attempting to visualize pathologic defects with subsequent roentgenograms

netted rather poor confirmations of clinical impressions. Rather than advise any formidable treatment on such grounds of insecurity, intraspinal lipiodol was employed in preference to air injections. In every case where oil was used, following removal of the herniated cartilage, the dura was opened and as much of the oil as possible was removed. This was accomplished usually by elevating the head of the operating table. This permitted an excessive loss of spinal fluid and accounted for the severe postoperative headaches that were so frequent. Postoperative roentgenologic examinations, made of a few of these cases, were convincing of the futility of attempting to recover all of the



A B

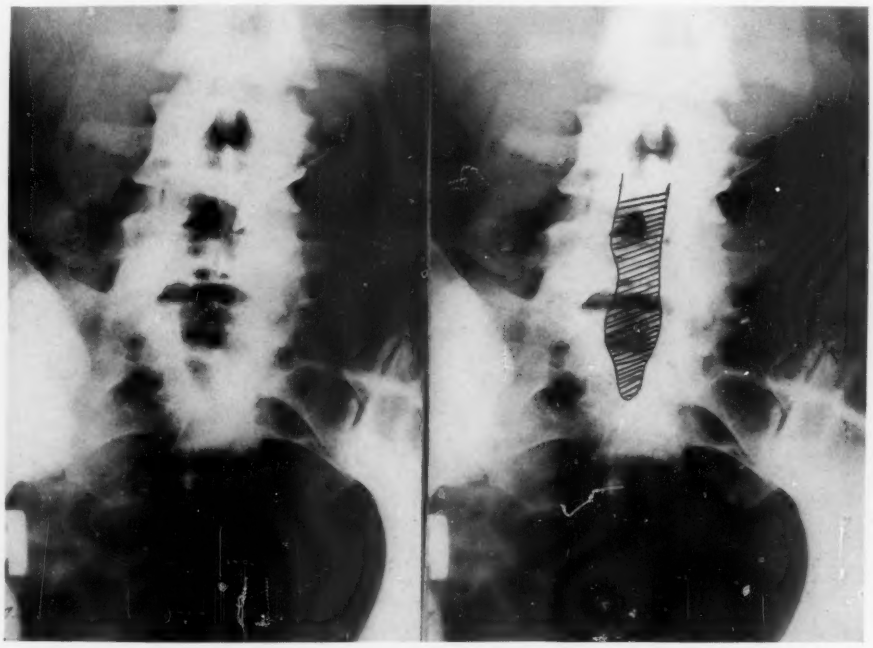
FIG. 1. A and B.—Spinograms more commonly depict a shift to the opposite side of the cartilaginous spinal protrusion.

previously injected oil. In no instance was there a roentgenogram that did not show some residual lipiodol. The additional operative risk from opening the dura and the lessening of actual operating time, were other influences in making further attempts to visualize the herniated cartilages with air.

In the more recent cases that have been operated upon, the cartilage defects have been visualized with intraspinal air. Such visualization is not as clear cut and convincing as are the lesions when depicted with lipiodol. Leading to the change in roentgenologic studies in clinical cases of protruded disks, four cases were studied, both with air and lipiodol, and in three of these the spinal defects coincided so definitely as to exclude any doubts as to the possibilities of air visualizations of protruded disk. In one, the roentgenograms made with air were not convincing enough and oil injection outlined the intraspinal defect. In a comparative review of the earlier experiences with air injection there were five cases; these all had subsequent injections of 5 cc.

of lipiodol, and, in retrospect, only two of these, at present, would possibly be subjected to fluoroscopic lipiodol study.

In using air, where the lesions are suspected as located between the fourth and fifth lumbar interspace or the interspace below, only 20 cc. of air has been necessary. By keeping the lumbosacral canal at a level higher than the patient's head, it has been possible with this small amount of air to visualize the spinal canal as high as the second lumbar level. By keeping the patient's head lowered for 24 hours, discomforts from subarachnoid cerebral air have been



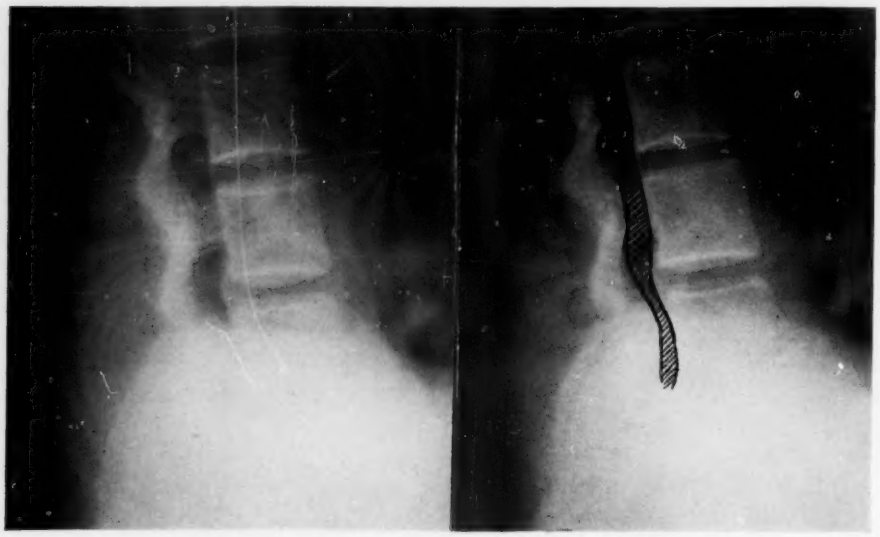
A B

FIG. 2. A and B.—Air injected into the subdural instead of the subarachnoidal space gives the isolated defects so well depicted on lipiodol studies.

minimized. In more than half of the cases in which air studies have demonstrated the displaced cartilage, there has been a reproduction, and often an exaggeration of the patient's original complaints. In the unilateral painful radiations this has occurred regardless of whether the painful side was or was not the dependent one at the time of the lumbar sac insufflation. This reproduction of pain has been of some clinical help, but until a sufficient number of observations have been made in order to justify definite conclusions, no worth while value has been attached to this reaction. There have been no serious reactions to lipiodol, and in the face of doubtful roentgenologic air studies, it should be used in every instance to establish or exclude a herniated intervertebral cartilage before subjecting a patient to an exploratory laminectomy.

Utilizing a unilateral laminectomy approach to the exposure of the pro-

truding cartilage has helped minimize the risk of any sequelae that might develop from an alteration of the normal architecture of the vertebral column. This type of laminectomy has also obviated spine fusion. In the lesions located beneath the first sacral root a small rim of the first sacral arch on the side of the lesion and a removal of the overlying ligamentum flavum has afforded sufficient exposure for complete removal of the protruding cartilage. In a number of cases, where the lesion was located beneath the fourth lumbar laminal arch, a sacrifice of one posterior spine has permitted better exposure and allowed firmer muscle closure. Eight such patients have now been performing, for 12 months or longer, such strenuous manual labor as they were



A B

FIG. 3. A and B.—More commonly posterior displacements of air are visualized on spinograms which are more definite than the anteroposterior films suggest.

engaged in prior to their disabilities. These manual laborers have been quite free from pain or any recurrences of their former physical disability. Such have been the results in a larger number of cases where occupations did not necessitate physical labor. Of the 50 cases, 80 per cent have been satisfactorily relieved; the remaining 20 per cent are about equally divided into complete failures or some benefit. There have been four wound infections and no mortalities.

The criticisms that have been aimed at the treatment of low back pain and sciatica resulting from a displacement of the intervertebral cartilage into the spinal canal, have been directed toward the use of intraspinal lipiodol, and the formidableness of the operation necessary to remove the compressing lesion. Utilizing air so as to minimize the injection of lipiodol, approaching the lesion with as little destruction of bone as possible and leaving the dura intact are three measures to overcome the objections in this mode of treatment. There are unquestionably many patients with sciatica whose neurologic

symptoms and signs are so accurately explained physiologically and whose lesions can be so positively depicted that they are entitled to surgical relief.

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DISCUSSION.—DR. WALTER E. DANDY, Baltimore, Md.: Spinal surgery has indeed enlarged markedly since the field of ruptured intervertebral disks has been so intensively developed during the past few years. In 1929, I reported two cases, the first, I think, in the literature. At that time, it was emphasized that trauma was responsible; that sciatica and low back pain were outstanding symptoms in the early stages. Moreover, in this report the lesion was localized by lipiodol and removed surgically. Doctor Mixter, who is so frequently given credit for this discovery, and is so credited by Doctor Fincher, added nothing but the disclosure of the lesion in the early stages, before a complete block of the spinal canal had resulted. The early and late disks have been diagnosed by lipiodol, but for the early lesions such large amounts of this material have been used by Mixter that its employment, since it remains permanently, should be used only when little doubt remains from signs and symptoms that the lesion is a ruptured disk. The lipiodol is removed at operation. To avoid the use of these large amounts of lipiodol, spinal air injections have recently been employed by Doctor Fincher and others. If the roentgenographic picture is always sharp, as is shown in Doctor Fincher's films, it will be a great advantage. Years ago, I used spinal air injections to localize spinal tumors, and although beautiful results were obtained, the air shadows were, on the whole, not so sharply defined and the results were too capricious. Lipiodol was far superior and, in the small amounts necessary for this purpose, did not harm. For this purpose I have been using lipiodol in a much more restricted way. By using 1.5 to 2 cc. and placing the patient on the abdomen, with a lateral exposure, the line of the posterior border of the vertebral bodies can be so sharply delineated that a protruding disk cannot be missed. To do this, it is first necessary to sharply define the location of the lipiodol to the desired place in the vertebral column by fluoroscopy; after which the roentgenograms are taken. Even so, if air will as consistently and sharply define the lesion it will be better than lipiodol. This remains to be seen.

BRIEF COMMUNICATION

A CLAMP FOR CLOSURE OF THE DUODENAL STUMP IN GASTRIC RESECTIONS

A MODIFICATION OF THE FURNISS CLAMP

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ONE of the chief technical problems in subtotal gastrectomy is closure of the duodenal stump. Failure to make a water-tight closure of the cut end of the duodenum is responsible for one of the most serious of all complications following partial gastrectomy. When healing of the duodenal stump is incomplete, a duodenal fistula results. The keynote of successful closure is adequate mobilization of the duodenum and pylorus, a maneuver which is conducive to the easy application of clamps to the duodenum in thin patients. However, in obese and muscular patients, and in those where mobilization is incomplete owing to extension of the inflammatory process into the pancreas and lesser omentum, the application of standard clamps to the duodenum may be a very difficult procedure because the handles of the clamp and the crushing blades are on the same plane. Ineffective closure may be due to bleeding from inadequate crushing or to slipping of the clamp. The clamp here presented was devised to overcome this problem in technic.

Description of Clamp.—Many methods for closing the duodenum in gastric resection have been devised, and the use of various clamps has been advocated. The best of these, employing the principle of shirring the duodenal wall, is the Furniss[1] clamp. However, the handle of this clamp, since it is on the same plane as the blades, is awkward if the duodenum is difficult to mobilize. Too, the serrated edge is much longer than is necessary for clamping the duodenum. The Clute[2] modification of the Furniss clamp, while an improvement for duodenal closure, has the same disadvantage since the relative position of the handles is unchanged.

The clamp herein described and illustrated employs a principle independently developed by Stone[3, 4] namely, of using a detachable handle to close the clamp. The advantages of this are that the handle may be applied from any angle, and, when once the clamp is closed and locked, the handle may be removed. Thus, the clamp is rid of the disadvantage of the bulkiness inherent in clamps with fixed handles. The blades are exactly like those of the Furniss in design but are smaller, the length being two and three-quarters inches and the crushing surface measuring less than half an inch (Fig. 1).

The clamp is closed with the forceps handle, the jaws of which fit into small sockets at the open end of the clamp. The jaws of the forceps hold very securely in these sockets and are capable of exerting adequate crushing force. A sliding lock, located on the upper blade, secures the clamp in a closed position.

Submitted for publication March 2, 1939.

Method of Application.—The duodenum is mobilized by sectioning the lesser omentum attached to its first part, ligating the right gastric and right gastro-epiploic arteries, and separating the descending portion from the head of the pancreas. The mobilized organ is grasped with a ring clamp which elevates and steadies the structure. The clamp, with its hinged extremity directed toward the liver, is now applied to the duodenum at a point from 2 to 3 cm. above the lower limit of the cleared area. The forceps handle is applied, and the clamp is closed and locked. A Dulox needle swaged on No. 0 chromic catgut is then thrust through the opening in the clamp. It is important to introduce the needle before removing the detachable handle in order to fix the clamp securely. If this precaution is not taken, the clamp may slip off the cut end of the duodenum after the latter is sectioned. The advantages of a detachable handle are manifested by the ease of manipulation

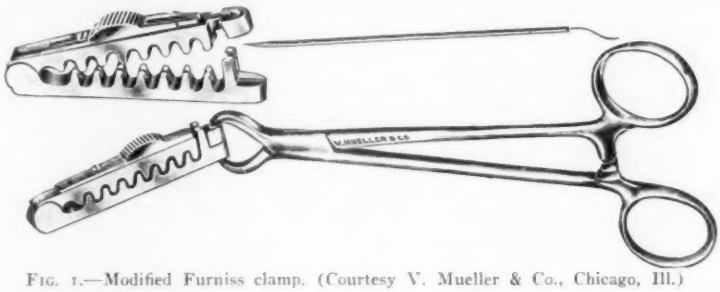

FIG. 1.—Modified Furniss clamp. (Courtesy V. Mueller & Co., Chicago, Ill.)

even when the duodenum lies in the depth of the wound and the exposure is not good. A Payr or Kocher clamp is placed above the special clamp and the duodenum is sectioned and, after swabbing the cut ends with antiseptic, the stomach is turned to the left. In certain cases where exposure is limited, suture of the duodenum may be deferred until after the desired portion of the stomach is resected. The routine technic is to unlock and remove the clamp, pull the needle through the crushed and shirred end of the duodenum and tie the sutures, thereby effectively controlling bleeding and closing the cut end of the duodenum. An inverting purse-string suture of fine silk followed by a double row of Lembert sutures of the same material completes the closure.

We have employed this clamp now in a series of 45 operations for partial gastrectomy and have continued to be impressed with its utility. Its outstanding features are ease of application and better control of the duodenal stump. Our improved mortality rate has been attributed in part, at least, to the use of this clamp. We now have performed 34 consecutive partial gastrectomies without a death, and of this group, only one patient developed a temporary duodenal fistula.

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MEMOIRS

EDMUND DOUGAN CLARK

1869–1938

EDMUND DOUGAN CLARK was born at Economy, Indiana, November 28, 1869, and died in Indianapolis, February 16, 1938. His father and grandfather were physicians, and he was a cousin of the late Dr. John T. Clark,

EDMUND DOUGAN CLARK, M.D.

of Philadelphia. His parents were Quakers, and Economy was one of the group of Quaker settlements in eastern Indiana. After graduation from the Economy High School, he studied two years at Earlham College in Richmond, Indiana. He then entered the Bellevue Hospital Medical College, from which he was graduated, in 1891. After a brief but exciting period of practice in Idaho, he spent three years on the surgical staff of the recently opened Johns Hopkins Hospital, and then studied abroad.

Doctor Clark came to Indianapolis in 1906. For a time he was Secretary and Pathologist of the City Board of Health. After this service he began the practice of surgery. He was among the first surgeons to come to Indiana with a good training in the new surgical technic and methods of clinical study. He had a large surgical practice from the beginning of his career. In 1908, he was one of a group of physicians which helped organize the Indiana University School of Medicine, which gave him the title of Professor of Surgery. In 1917, in the early days of the World War, he enlisted in the Medical Service of the United States Army, and was appointed Commander of Base Hospital No. 32, with the rank of Major. He remained in command of this unit until the close of the War, when he was made a Colonel in the Medical Reserve Corps. He received personal citations from the French Government and from General Pershing for his services.

Doctor Clark was President of the Indianapolis Medical Society in 1931, and President of the Indiana State Medical Association in 1937. He was a member of the Western, Southern and American Surgical Associations, and of the American College of Surgeons. He had a special affection for the Southern Surgical Association, because its membership included so many of his old friends.

During the later years of his life, Doctor Clark took a great interest in the administration of the Methodist Episcopal Hospital at Indianapolis, and did much to shape the policies and development of that institution.

His chief interests, apart from his professional activities, were golfing and trap shooting, in both of which sports he was exceedingly proficient. He was a genial companion and had hosts of friends, both lay and professional. He left a lasting influence on organized medicine in Indiana.

In 1893, he married Miss Harriette Lewis. She and a daughter, Mrs. Helen Talbott, survive him.

WILLIS D. GATCH.

FRANK S. LYNN

1884–1938

Dr. Frank S. Lynn died in the University Hospital, September 26, 1938, in his fifty-fourth year. His illness and death came as an unexpected shock to his many friends and associates.

Frank S. Lynn, M.D.

Doctor Lynn was a native of Baltimore, went through the five-year course at City College, where he was graduated in 1903, and that autumn began the study of medicine at the University of Maryland, graduating in 1907. He was an outstanding student and was the honor man in his class.

After graduation he was intern and resident surgeon in the University Hospital, and after completing this service he did postgraduate work at the University of Strasbourg where Professor Chiari, the famous pathologist,

was teaching. On returning to America he joined the surgical staff of the University Hospital and advanced rapidly through the different ranks of University service from Instructor in Surgery (1911–1914), Associate in Surgery (1914–1916), Associate Professor of Surgery (1916–1926), Clinical Professor of Surgery (1926–1932) to Professor of Clinical Surgery, 1932, until his death. From 1911 until a few years ago, he was Assistant Surgeon-in-Chief at the City Hospitals and during all these years he carried a heavy burden of teaching to undergraduates, in the training of house officers and the care of surgical patients in all departments of the University and City Hospitals. He also found time for work in other hospitals and was a well-known figure in the surgical life of Baltimore.

When the medical care of prisoners in the Penitentiary and the House of Correction was reorganized about 20 years ago, he undertook the responsibility for the surgical care of inmates in both of these prisons. He was also assistant to the chief surgeon of the Baltimore and Ohio Railroad.

He was keenly interested in the Baltimore City Medical Society and the Medical and Chirurgical Faculty of Maryland, and was always ready to perform any service asked of him by his medical brothers. He served on many committees; was Secretary of the Baltimore City Medical Society from 1919 to 1923 and President in 1935. He was especially interested in hospital insurance and took a very active part in the different phases of this very important modern hospital service during its development in Baltimore. When he died he was a director, representing the medical profession in the Associated Hospital Service of Baltimore and First Vice-President of the Medical and Chirurgical Faculty of Maryland.

He did not shirk his obligations, and was active in the many organizations in which membership is often part of a physician's duty. Honors and recognition came to him also. He was a member of the American Surgical and the Southern Surgical Associations and many local clubs, both medical and lay, wherein men of similar ideals and standards enjoy companionship. In the midst of this busy and, to him, very interesting life, he found time to write. His more recent papers are: "The Diabetic from the Surgical Standpoint"; "Postoperative Gangrenous Ulcer of the Abdominal Wall"; "The Elective Transverse Abdominal Incision"; "The Surgical Consideration of the Typhoid Carrier."

To those of us who were associated with Doctor Lynn, his spirit seemed always young and it is hard to think of him as being dead. He had a vivid and dynamic personality. If the term magnetic may be used to describe human attributes, this adjective is descriptive of him. His presence in any group was a challenge against indifference, inaccuracy, carelessness and procrastination. His honesty and fearlessness were an integral part of his character. One might not agree with him, but it has been a striking thing that in his passage through life those who differed with him most loved him best.

As teacher, leader and operator, undergraduates, house officers and

younger physicians found in him a never failing stimulus to better work. His keenness, energy, conscientiousness and never faltering interest were like so many lights to guide and encourage them, for in him there dwelt a brave and crusading spirit that fronted the manifold problems of living with zest and without guile.

ARTHUR M. SHIPLEY.

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